Thermo
ELECTRON CORPORATION

DCT6088

DEDICATED DIGITAL CORRELATION TRANSIT TIME ULTRASONIC FLOWMETER

USER MANUAL

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Thermo
ELECTRON CORPORATION

USER MANUAL

DCT6088 DEDICATED TRANSIT TIME
ULTRASONIC FLOWMETER
FIRMWARE VERSIONS 6.00 ONWARD
FEBRUARY 2003
REV. B

NOTICE

Read this manual before working with the product. For personal and system safety and for optimum performance, make sure you thoroughly understand the contents before installing, using, or maintaining your transit time instrument.

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1. Product Overview

1.1 Introduction

The DCT6088 Digital Correlation Transit Time Flowmeter is manufactured by Thermo Electron Corporation. This microprocessor-based instrument measures the flow of clean, homogeneous liquids (liquids without large concentrations of suspended particles or gasses such as air bubbles). The flowmeter is noninvasive, which means that it measures flow from outside the pipe. Its transducers can be mounted to a pipe within a matter of minutes, and flow measurements may be made without interrupting the flow or modifying pipework.

The DCT6088 can be configured using an integral keypad for entering variables such as pipe size, pipe material, wall thickness, and fluid type (refer to Section 4.5, page 14).

1.2 Theory of Operation

Sound waves travel in fluids at a specific velocity depending on the type of fluid. If the fluid is moving, the sound wave travels at a velocity equal to the sum of the speed of sound in the fluid and the velocity of the fluid itself relative to the transducer. A sound wave traveling in the same direction as the fluid flow (downstream) will arrive sooner than a sound wave traveling against the flow (upstream). A transit time flowmeter operates by measuring both the absolute travel time of each sound wave and the difference in time required for the waves to travel between an externally mounted downstream and upstream transducer (Figure 1.2-A, below). Based on the transit time of the 2 sound waves, the flowmeter calculates the average fluid velocity.

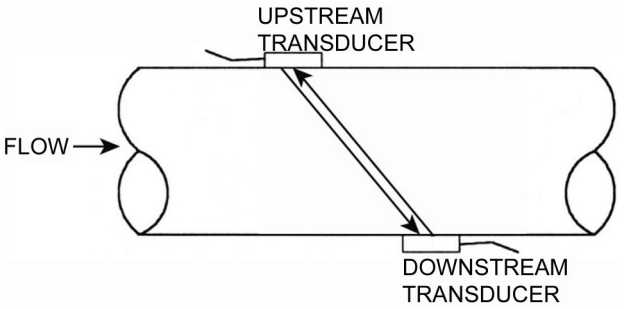


Figure 1.2-A: Typical Transit Time System

Once the differential transit time is calculated, several additional variables must be taken into consideration. The overall velocity of the fluid is actually made up of many individual local velocities that vary according to their distance from the pipe wall. The velocities in the center of the pipe are higher than the velocities near the pipe wall. The combination of these individual velocities for a specific type of fluid within a specific pipe yield a velocity distribution known as the flow profile (Figure 1.2-B, page 2), which is a function of the Reynolds number. By properly configuring the flowmeter, the effects of the flow profile are taken into consideration when calculating the mean fluid velocity. The flowmeter then multiplies this velocity by the pipe's cross-sectional area to obtain volumetric flow.

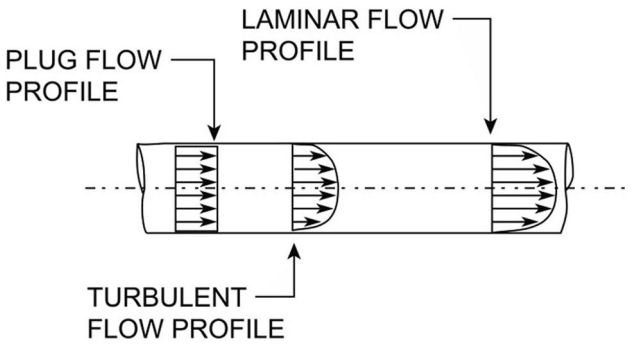


FIGURE 1.2-B: FLOW PROFILES

1.3 Transit Time Accuracy

Noninvasive ultrasonic measurements are subject to a variety of effects that can influence measurement accuracy. All ultrasonic instruments are velocity measuring devices and only infer volumetric flow from the operator-entered parameter of pipe inside diameter (ID). When this value is squared to get cross-sectional area, a 1% error yields a 2% error in volumetric flow. In practice, commercially fabricated pipe seldom has ID consistency much tighter than 1%, and unless the pipe to be measured has been accurately measured, this uncertainty is not reducible through instrument calibration.

The more sophisticated transit time flowmeters incorporate flow profile corrections to compensate for the pipe's cross-sectional velocity profile with a changing Reynolds number. However, this requires that the operator knows the inside roughness of the pipe to be measured. The instrument may infer a roughness if none is entered by the operator, but that is only an estimate based on the characteristics of new pipe. Pipes can, of course, accumulate deposits which may not only reduce the ID, but affect the roughness as well. Errors on the order of 2% as a result of this phenomenon are not uncommon.

While other factors may influence instrument accuracy to a lesser extent, the issues described above are the major elements of pipe dependency upon absolute instrument accuracy. While calibration on a reference flow loop under known conditions is a useful exercise to determine the accuracy potential of an instrument, it is not a guarantee of absolute accuracy on different pipes under field conditions.

1.4 Ordering

The table below describes ordering information for a standard DCT6088 flowmeter as well as available options.

MODEL NUMBER

Series: Digital Correlation Transit Time Flowmeters

DCT6088 = DCT6088, RS232 digital interface with UltraScan signal analysis and configuration program

Display

1 = 40-character, 2-line alphanumeric LCD[1]
2 = vacuum fluorescent display

Relays

1 = 1 relay: 5-A, SPDT, fully programmable[1]
2 = 2 relays: 5-A, SPDT, fully programmable
3 = 3 relays: 5-A, SPDT, fully programmable
4 = 4 relays: 5-A, SPDT, fully programmable
5 = 1 metal cased relay: 3-A, SPDT, fully programmable
6 = 2 metal cased relays: 3-A, SPDT, fully programmable
7 = 3 metal cased relays: 3-A, SPDT, fully programmable
8 = 4 metal cased relays: 3-A, SPDT, fully programmable
9 = no relays installed

Enclosure

1 = NEMA 4X (IP65)[1] **2** = NEMA 7

Transducer Cable Length

30A = 30 ft (9 m)[1] **XXXXA** = increments of 10 ft (3 m) up to 1000 ft (305 m)

Transducer Hazardous Area Certification

A = CSA: Class I, Div. 2, Groups A, B, C, D; Class II, Div. 2, Groups E, F, G[1]
B = CSA: Class I, Div. 1, Groups C, D; Class II, Div. 1, Groups E, F, G*
C = CENELEC (LCIE): EEx ia IIB T6*
***IS barriers installed in the transmitter

Typical Model Number: DCT6088-1-2-1-30A-A

[1] standard
[2] Relay codes 1 through 4 are NOT suitable for hazardous area applications unless the NEMA 7 enclosure is selected for the transmitter. If relays are required and the transmitter is to be located in a Class I, Div. 2 environment, relay codes 5 through 8 are applicable.
[3] Intrinsically safe (IS) barriers installed in the transmitter at the factory for this certification.

TABLE 1: ORDERING INFORMATION

1.5 Technical Specifications

1.5.1 Performance

Flow range:	0 to 40 ft/s (0 to 12 m/s)
Accuracy:	+/-1% of velocity or +/-0.05 ft/s (+/-0.0152 m/s), typical, digital output
Sensitivity:	0.001 ft/s (0.3 mm/s) at any flow rate, including zero
Linearity:	+/-0.1% of scale, digital output
Pipe size:	1 to 200 in (25 mm to 5 m)
Pipe material:	aluminum, asbestos, carbon steel, cast iron, copper, ductile iron, fiberglass-epoxy, PVC, PVDF (low and high density), stainless steel
Liner material:	ebonite, mortar, polyester, polyethylene, polypropylene, polystyrene, polystyrol, rubber, tar epoxy, teflon

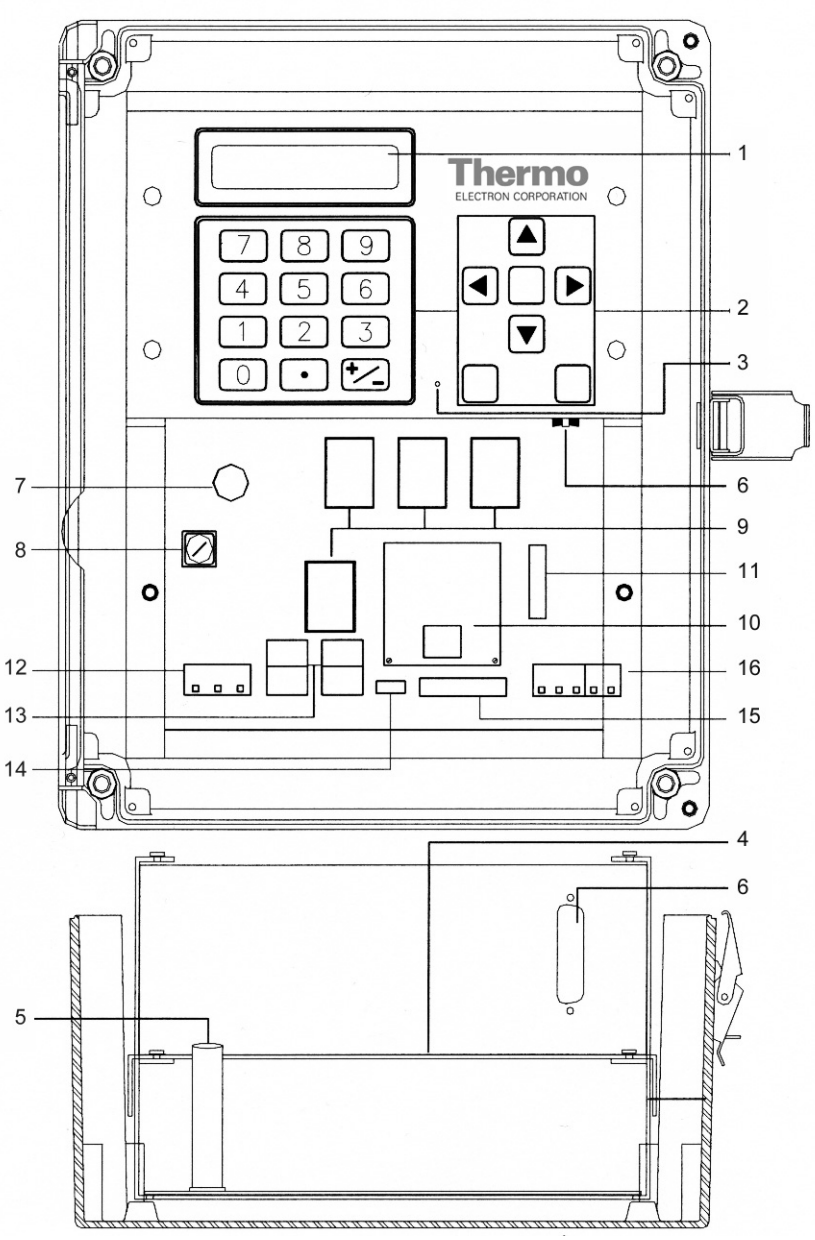
1.5.2 Functional

Outputs:	4-20 mA (into 1000 ohms), 12-bit, 5 kV opto-isolated, loop- or self- powered RS232 serial interface
Power supply:	90 to 132 Vac and 190 to 250 Vac, 50/60 Hz (standard, switch-selectable) 12 to 24 Vdc (optional)
Keypad:	19-key with tactile action
Display:	40-character, 2-line, alphanumeric, backlit LCD
Datalogger:	30,0000 points, time stamped; programmable in 1-second intervals
Relays:	5-A, SPDT, fully programmable; 1 relay standard, up to 4 relays available
Programming:	via UltraScan utility (supplied with flowmeter) OR integral keypad
Temperature Range:	*Transducers:* -40º to +212º F (-40º to +100º C) *optional high temperature transducers available* *Transmitter:* -40º to +140º F (-40º to +60º C)
Humidity limits:	0 to 100% relative humidity

1.5.3 Physical

Transmitter:	NEMA 4X (IP65), flame-retardant, fiberglass-reinforced polyester (standard) NEMA 7 (optional)
Transducers:	encapsulated design with standard 30 ft (9 m) cable length; suitable for submersible/underground service
Weight:	approximately 12 lbs (5.4 kg) without options

1.6 External Features



Components

#	Description
1	Liquid crystal display (LCD): displays configuration selections, flow rate, totalized flow, etc.
2	Keypad: for selecting display screens and configuring instrument
3	Power-on indicator
4	Sheetmetal access cover: provides access to wiring terminals and other components
5	Fuse access hole
6	DB25 connector for RS232 communications
7	Input voltage selection switch: for selecting 120 or 240 Vac operation
8	Fuse
9	Location of optional relays (1 standard)
10	4-20 mA current loop module
11	COM terminal block
12	AC input terminal block: for connecting to power inputs
13	Relay terminal blocks: for connecting to relay outputs
14	MUX interface connector
15	AUX terminal block
16	Transducer terminal block

2. INSTALLING THE SYSTEM

Observe the following precautions for the installation procedures outlined in this chapter:

- **Power connections MUST be made in accordance with local standards or codes of practice.**

- **Avoid potential injury or damage to equipment–ensure that the flowmeter is grounded at ALL times.**
- **Minimize the possibility of explosion in hazardous area installations–do NOT disconnect power until the area is known to be nonhazardous.**

- **Prevent the possibility of electrical shock or damage to the instrument–disconnect power PRIOR TO removing the sheetmetal access cover. Replace the cover before reconnecting power to the unit.**

2.1 Installing the Enclosure

The enclosure should be mounted to a sturdy vertical surface such as a wall. The enclosure can be directly mounted with screws or indirectly mounted with mounting ears. The flowmeter has 5/16-inch, metal threaded inserts located in the corners of the enclosure. The inserts are located in mounting wells that are sealed from the interior of the enclosure when the door is closed, which prevents moisture from entering the instrument through the mounting holes.

2.1.1 Direct Mount Method

The enclosure can be directly mounted to a wall by inserting 4, 1/4-inch screws into the mounting wells from the front of the enclosure. The screws act as “through bolts” for securing the unit to the wall.

2.1.2 Mounting Ears Method

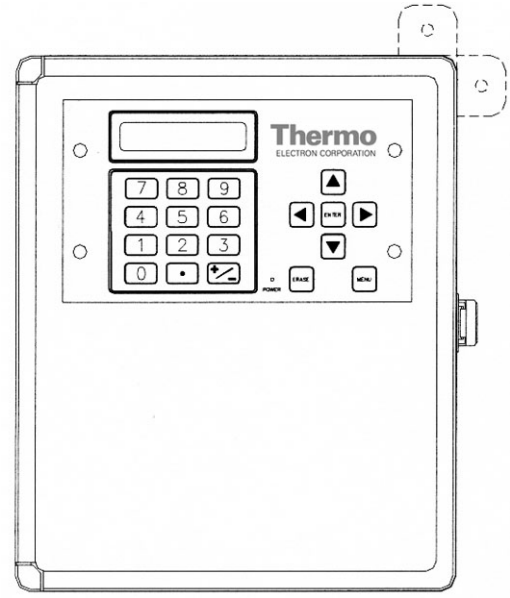


FIGURE 2.1

The enclosure can be mounted to a flat, vertical surface using the optional mounting ears. The mounting ears can be oriented vertically or horizontally as follows:

1. Screw the 4 mounting ears to the metal threaded inserts on the back of the enclosure using the 5/16-inch screws provided in the mounting ears kit.

2. Attach the ears to the wall with standard mounting screws.

2.2 Connecting the Wiring

All wiring should be routed through conduit or cable glands to seal the enclosure. Refer to Figure 2.2 (below) for the recommended cable routing.

IMPORTANT: Bonding between conduit connections is NOT automatic and must be provided as a part of the installation.

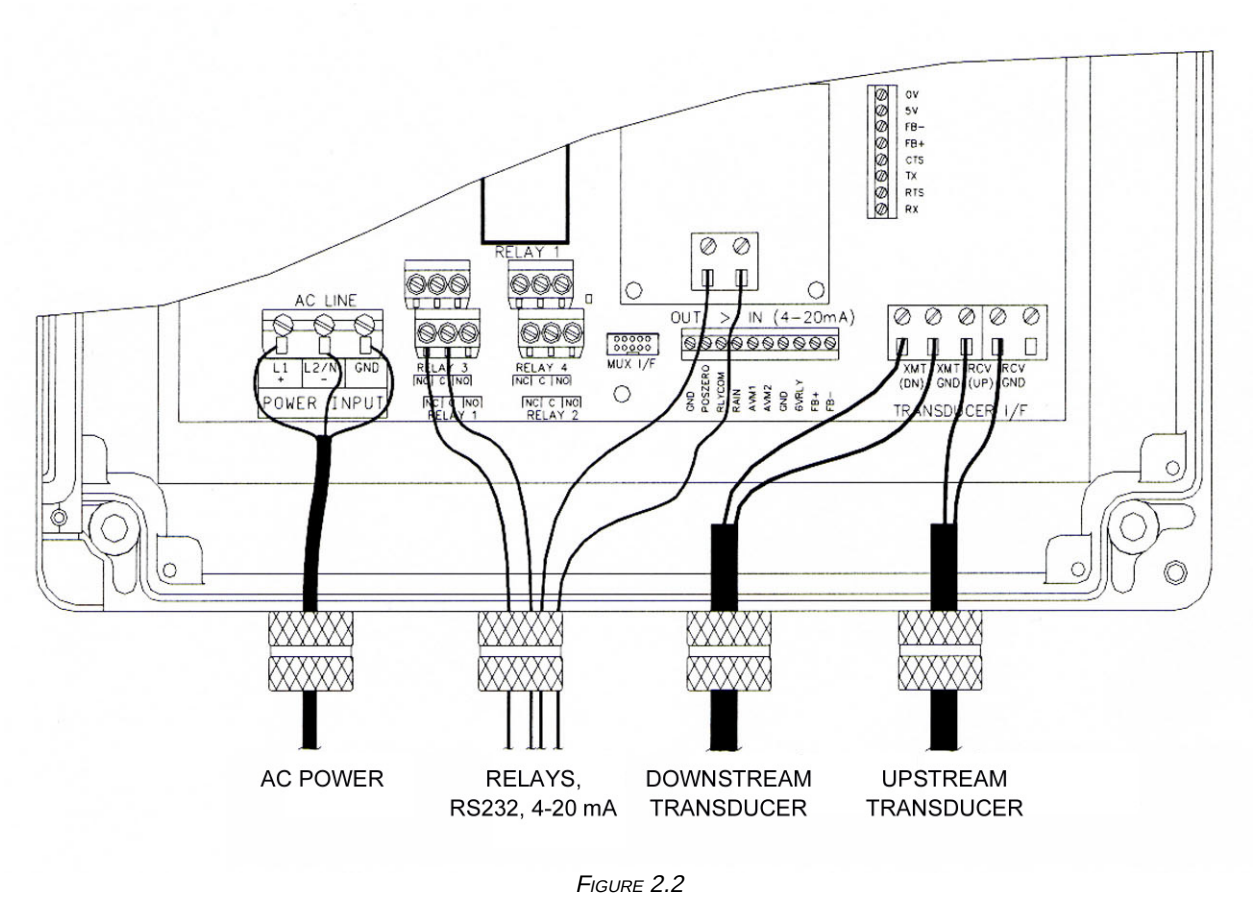


FIGURE 2.2

To prevent damage to the instrument, verify that the voltage to be connected matches the voltage rating of the flowmeter. The voltage rating is indicated beneath the power input terminals.

The power input terminals seen in Figure 2.2 (above) can be connected to one of the following input voltages:

- 120 Vac, 50/60 Hz: setting should be on 110;
- 240 Vac, 50/60 Hz: setting should be on 220;
- 12 to 24 Vdc: setting should be on 110.

...2.2 Connecting the Wiring continued

Prevent possible electrical shock and/or damage to the meter–disconnect power to the meter PRIOR to wiring.

Power should be connected in accordance with local standards or codes of practice.

For DC-powered flowmeters, set the 4-20 mA current loop function to loop-powered mode to prevent ground loops.

To connect the power, remove the sheetmetal access cover. Locate the individual power input terminals; they are marked directly on the main board or on a sticker attached to the main board. Connect the power.

- **120 Vac operation:**

  1. Connect the **hot wire to the *L1* (+)** terminal.
  2. Connect the **neutral wire to the *L2/N (-)*** terminal.
  3. Connect the **ground wire to the *GND*** terminal.

- **Single Phase 240 Vac operation:**

  1. Connect the **live wire to the *L1 (+)*** terminal.
  2. Connect the **neutral wire to the *L2/N (-)*** terminal.
  3. Connect the **ground wire to the *GND*** terminal.

- **Double Phase 240 Vac operation:**

  1. Connect **1 hot wire to the *L1 (+)*** terminal.
  2. Connect the **other hot wire to the *L2/N (-)*** terminal.
  3. Connect the **ground wire to the *GND*** terminal.

- **12 to 24 Vdc operation:**

  1. Connect the **positive wire to the *L1 (+)*** terminal.
  2. Connect the **negative wire to the *L2/N (-)*** terminal.

3. Additional Wiring Instructions

3.1 Current Loop Terminals

The 4-20 mA current loop module has an input terminal and an output terminal, which are indicated on a label on the inside of the flowmeter door. The current loop output is rated for a loop resistance of up to 1 k ohms and is isolated for up to 5 kV when loop-powered.

The 4-20 mA module is shipped with the current loop self-powered. Switch the module to loop power by moving a jumper on the module. Current loop modules which are loop-powered must be driven from an external power supply. In this case the flowmeter acts as a passive 2-wire transmitter.

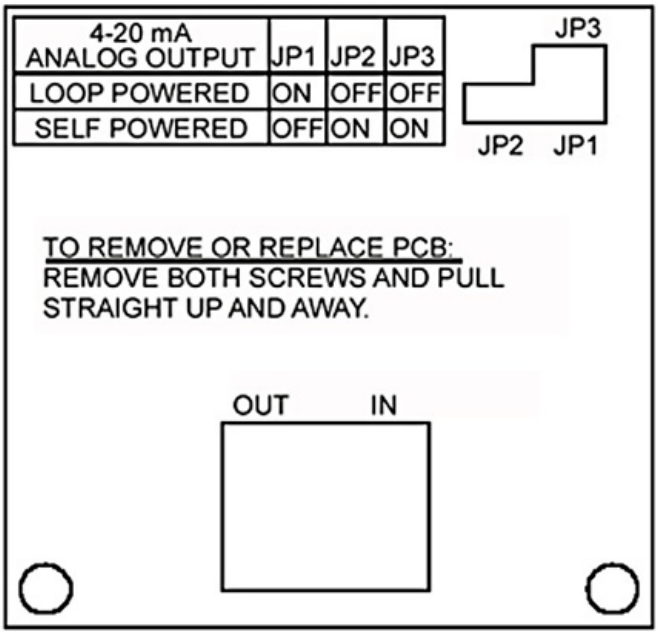
Prevent possible electrical shock and/or damage to the meter–disconnect power to the meter PRIOR to wiring.

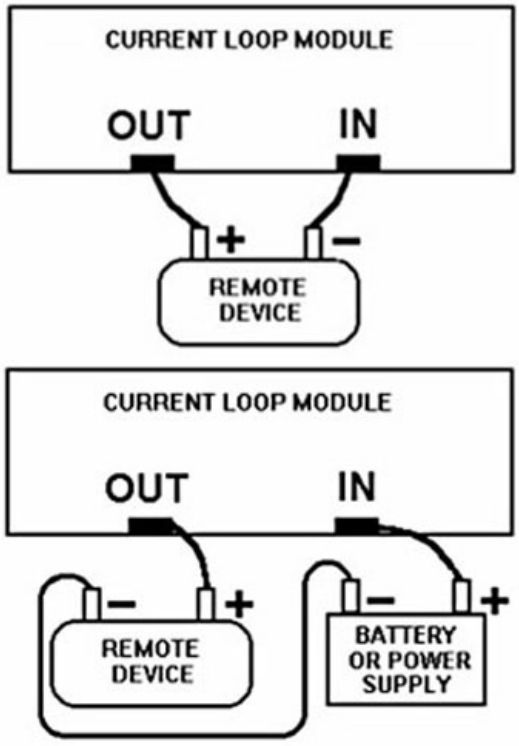
To connect the current loop:

1. Ensure the loop powering option is correct.

2. Locate the jumpers on the upper right corner of the module. Refer to Figure 3.1-A (below) to change the jumper settings.

3. Refer to Figure 3.1-B (below) for the self-powered option or Figure 3.1-C (below) for the loop-powered option.



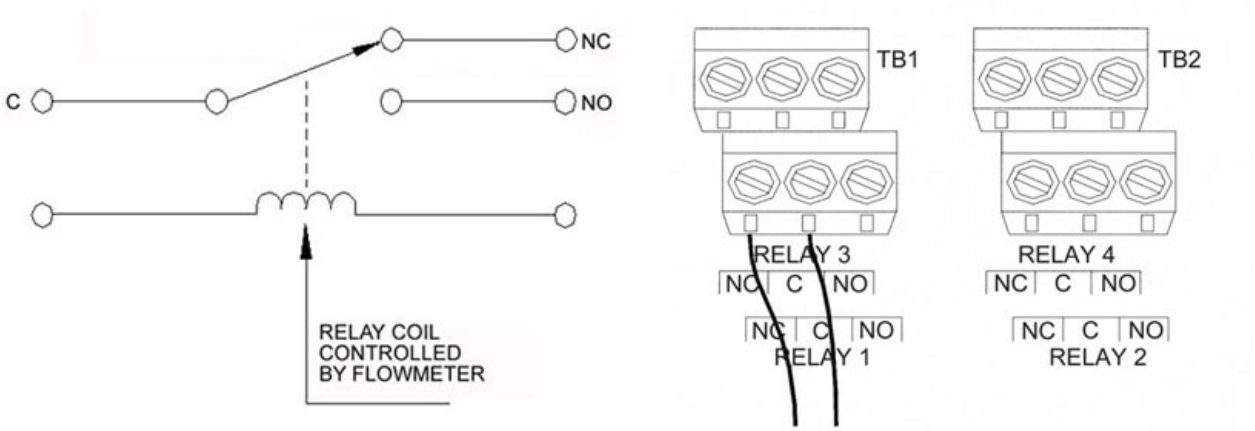


Figures 3.1-A (left), 3.1-B (right, top), 3.1-C (right, bottom)

3.2 Relay Terminals

Up to 4 relays may be installed in the DCT6088. The relays are rated at 5 A, 250 Vac. Each relay contains a normally open and normally closed dry contact accessible at the terminal blocks. The terminals for the relay are labeled on the module as **NO (normally open), C (common), and NC (normally closed).** When the relay is energized, the C terminal is shorted to the NO terminal (Figure 3.2-A, below). When the relay is at rest, the C terminal is shorted to the NC terminal.

The terminal blocks for the relays are labeled on the board as *RELAY 1* through *RELAY 4*. The relay terminal blocks should be wired for either NO or NC circuits. Figure 3.2-B (below) shows that relay 1 is wired for a NC circuit.



FIGURES 3.2-A: RELAY SCHEMATIC (LEFT) & 3.2-B (RIGHT)

NOTE **The auxiliary terminal block is designed for future feature development.**

3.3 Communications Terminal Block

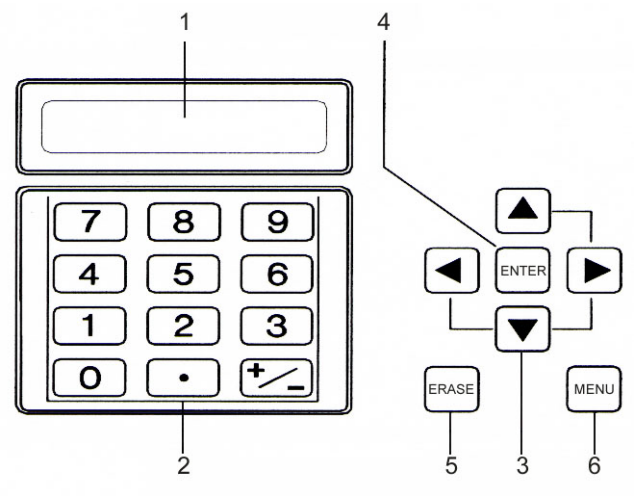
The communications terminal block is designed for future feature development.

4. Configuring & Operating the Flowmeter

4.1 The Keypad & Display

The keypad provides access to the microprocessor for flowmeter configuration. During operation, the instrument's 40-character LCD indicates flow rate and totalizer values. The display is also backlit for ease of viewing in low-light conditions and has a variable contrast setting.

4.1.1 Components



Components

#	Description
1	LCD
2	Numeric keys: **0** through **9** and decimal (**.**)
3	Arrow keys: for scrolling up, down, left, right
4	**ENTER** key: operates like the Return (Enter) key on a computer
5	**ERASE** key: deletes last value entered; in most setup anddiagnostic menus, accesses Main Menu; accesses Menu 00 (flow rate and net totalizer display) if pressed twice
6	**MENU** key: provides access to setup and diagnostic menus

Figure 4: Keypad & Display Features

4.1.2 Adjusting the Contrast

You may need to adjust the contrast on the display as ambient temperature changes:

1. Press **MENU** followed by the **±** (plus/minus) key.
2. *LCD CONTRAST* appears on the display with a bar indicating current contrast setting.
3. Press **LEFT** or **RIGHT ARROW** keys to adjust the contrast.
4. Press **ENTER** when complete.

4.2 Direct Menu Access

The unique 2-digit address (reference Table 2, page 12) for each setup and diagnostic menu allows the user to directly access the desired menu:

1. Press **MENU**, and the letter ***M*** appears in the lower right corner of the display.
2. Enter the desired menu's 2-digit address.

The address must be entered while the ***M*** is displayed (within approximately 4 seconds). If the ***M*** is no longer displayed, press **MENU** again followed by the 2-digit address.

Table 2: Menu Addresses

Menu Type	Display	Menu
Primary	Flow/Net Totalizer	00
	Flow/Velocity	01
	Flow/Positive Totalizer	02
	Flow/Negative Totalizer	03
	Signal Strength/Low Signal Cutoff	04
Pipe	Pipe OD	10
	Pipe Wall Thickness	11
	Pipe ID	12
	Pipe Material	13
	Pipe Sound Speed	14
	Pipe Inside Roughness	15
Liner	Liner Material	16
	Liner Thickness	17
	Liner Sound Speed	18
	Liner Inside Roughness	19
Fluid	Fluid Type	20
	Fluid Sound Speed	21
	Fluid Viscosity	22
Transducer	Transducer Type	23
	Transducer Mounting	24
	Transducer Spacing	25
Flow	Flow Units	30
	Max Flow Range	31
	Min Flow Range	32
	Damping	33
	Low Flow Cutoff	34
	Low Signal Cutoff	35

Menu Type	Display	Menu
Totalizer	Totalizer Units	36
	Totalizer Multiplier	37
	Net Totalizer	38
	Positive Totalizer	39
	Negative Totalizer	40
	Totalizer Reset	41
Options	Measurement Units	42
	Site Parameters	43
	RS232 Configuration	46
	Change System Password	47
	Change Scale Factor Password	48
	Unit ID	49
Calibration		50
	Zero Set	51
	Scale Factor	52
	Sound Speed Compensation	53
	Date and Time	54
Current Loop		56
	Current Loop Span	57
	Current Loop Calibration	58
	Current Loop Test	59
Relays		70
	Program Relays	71
	View Relays	72
	Test Relays	73
Datalog		80
	Datalog Interval	81
Diagnostics	Signal Strength/Margin	90
	Delta Time/Fluid Sound Speed	91
	Reynolds #/Profile Factor	92
	Current Loop Output	93
	Software/Firmware Rev. Level	94

4.3 Using the Arrow Keys to Access Menus

Another method of accessing the flowmeter's menus is to use the **LEFT** or **RIGHT ARROW** keys to scroll through the menu structure. Menus are organized into 3 basic levels: 1) main menu, 2) submenus, and 3) primary displays, setup menus, diagnostic menus. The **Main** menu displays various **submenus**, which contain individual **setup** and **diagnostic** menus.

To access the **Main** menu from any screen:

1. Press **MENU** twice. The Main menu is displayed with the **Pipe** and **Liner** submenu options as shown in Figure 4.3-A.

FIGURE 4.3-A

2. To view the remaining submenus (Figure 4.3-B), press the **DOWN ARROW** key.

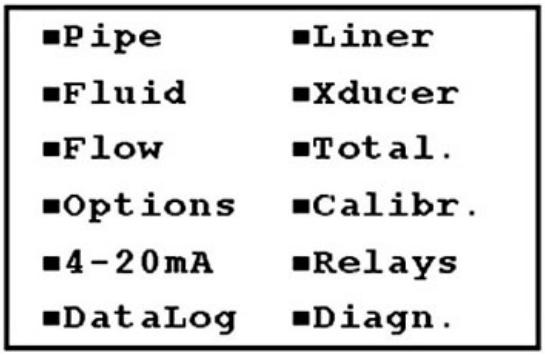


FIGURE 4.3-B

3. When the desired submenu is highlighted, press **ENTER** to display the first menu of the selected submenu. Figure 4.3-C is an example of when the **Flow** submenu is selected.

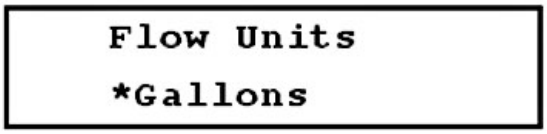


FIGURE 4.3-C

Use the **UP** or **DOWN ARROW** keys to view a **Primary Display, setup** menu, or **diagnostic** menu within the current submenu.

4.4 Flowmeter Configuration Using Setup Menus

Flowmeter configuration is accomplished using the setup menus. Some setup menus allow a numeric value to be entered, and others offer non-numeric selections. In non-numeric setup menus, an asterisk is displayed to the left of the selected currently entered in the flowmeter (Figure 4.4, below).

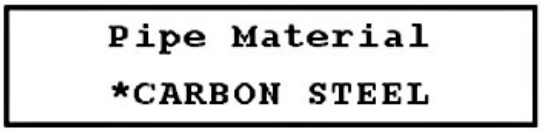


FIGURE 4.4

...4.4 Flowmeter Configuration Using Setup Menus continued

To configure the flowmeter:

1. Access the setup menus individually by pressing **MENU** and entering the 2-digit address OR by scrolling through the submenus and selecting the desired setup menu.

2. a. If the setup menu requires a numeric entry, use the numeric keys to enter the value and press **ENTER** to accept the value. If the numeric value is entered incorrectly, press **ERASE** to delete the entry.

   OR

   b. If the setup menu offers a non-numeric selection, press **ENTER**, and the asterisk changes to a flashing cursor. Use the arrow keys to scroll through the available selections. When the cursor is to the left of the desired selection, press **ENTER**.

3. Complete the configuration process by accessing a Primary Display (menus 00 through 04).

NOTE **The flowmeter will not use the new parameters until accessing a Primary Display.**

4.5 Quick Setup Configuration

The Quick Setup procedure contains the minimal steps required for flowmeter configuration. These steps enable the flowmeter to calculate transducer spacing, acquire ultrasonic signal, and measure flow. The number in parentheses after the required menu is the 2-digit address to directly access that menu.

1. Select a proper transducer site according to Section 6 (page 32).

2. Access the **Pipe** submenu. This submenu contains setup menus related to the pipe parameters such as pipe inside diameter (ID) and pipe outside diameter (OD).

NOTE **Pipe Wall Thickness is an additional setup menu within the Pipe submenu. If parameters for any 2 of the following 3 setup menus are entered, the flowmeter calculates the remaining parameter automatically: Pipe OD (10), Pipe Wall Thickness (11), Pipe ID (12).**

NOTE **Accuracy is directly affected by the square of an error in pipe dimensions; actual measurements (not nominal) must be entered.**

   a. Select the **PIPE OD** menu (10). Figure 4.5-A is displayed. Enter the value for the pipe OD and press **ENTER**. Press the **DOWN ARROW**, and select **Actual.**

   NOTE: If you know the pipe circumference but not the OD, enter the circumference value instead and press **ENTER**. Press the **DOWN ARROW**, and Figure 4.5-B is displayed. Select **Circum.** The flowmeter calculates the pipe OD automatically.

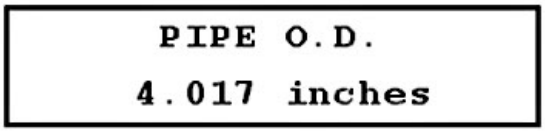


FIGURE 4.5-A

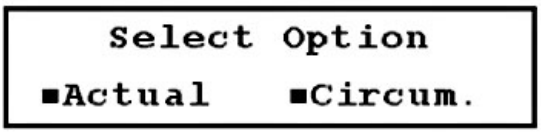


FIGURE 4.5-B

...4.5 Quick Setup Configuration continued

Step 2, **PIPE** setup menu continued:

b. Select the **Pipe ID** setup menu (12). Enter the pipe ID value, and press **ENTER.** (Figure 4.5-C)

c. Select the **Pipe Material** setup menu (13). Press the **UP** and **DOWN ARROWS** to scroll through the available options. (Figure 4.5-D)

NOTE: Select **OTHER** if the material is not listed. You must then enter then pipe sound speed (14) and pipe inside roughness (15).

3. If there is a liner:

   a. Access the **Liner Material** setup menu (16), and Figure 4.5-E is displayed. Press the **UP** and **DOWN ARROWS** to scroll through the available options.

   NOTE: Select **OTHER** if the material is not listed. You must then enter the liner sound speed (18) and liner inside roughness (19).

   b. Access the **Liner Thickness** setup menu (17), and enter the thickness. (Figure 4.5-F)

4. Access the **Fluid Type** setup menu (20), and scroll through the available options using the **UP** and **DOWN ARROWS.** (Figure 4.5-G)

   NOTE: Select **OTHER** if the fluid type is not listed. You must then enter the fluid sound speed (21) and fluid viscosity (22).

5. Within the **Transducer** submenu:

   a. Access the **Transducer Type** setup menu (23). Currently, the only selection available is **STANDARD**, which MUST be selected for all applications using clamp-on transducers, including high temperature transducers. (Figure 4.5-H)

   b. Access the **Transducer Mounting** setup menu (24), and select the desired mounting method. (Figure 4.5-I)

6. Access the **Transducer Spacing** view-only menu (25). Note the required spacing between transducers. (Figure 4.5-J)

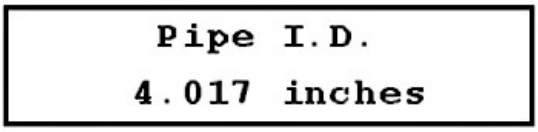


FIGURE 4.5-C

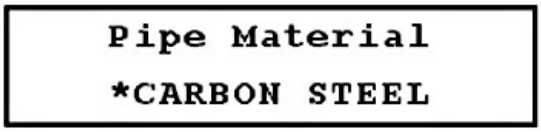


FIGURE 4.5-D

FIGURE 4.5-E

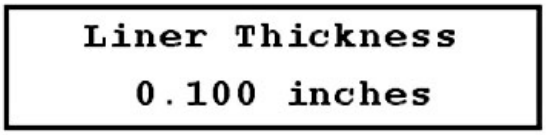


FIGURE 4.5-F

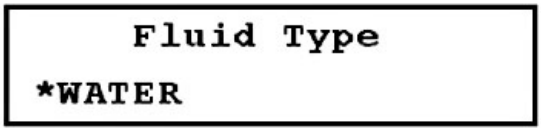


FIGURE 4.5-G

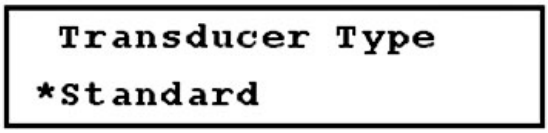


FIGURE 4.5-H

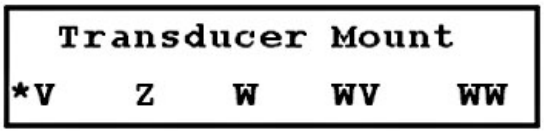


FIGURE 4.5-I

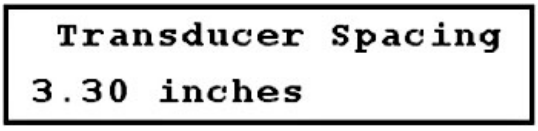


FIGURE 4.5-J

...4.5 Quick Setup Configuration continued

7. Access the **Flow Units** setup menu (30) within the **FLOW** submenu. Use this setup menu to select the flow rate units. Volumetric units are displayed first, followed by the associated time per units.

   a. Select one of the available volumetric units. (Figure 4.5-K)

   b. Press the **DOWN ARROW** and the time per unit options are displayed. Select the desired option. (Figure 4.5-L)

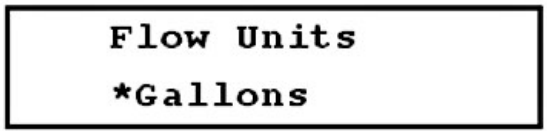


FIGURE 4.5-K

FIGURE 4.5-L

8. Install the transducers on the pipe using the spacing provided by the flowmeter, and connect the transducer cables to the flowmeter.

9. Access a **Primary Display** (00 through 04) to complete the configuration process.

If the flowmeter and transducers are properly installed and a steady flow is present, the flow and signal strength readings should be relatively stable.

If any of the above setup parameters are changed, the flowmeter stops measuring flow until the new value is entered and a Primary Display is accessed to accept the new value.

4.6 Primary Displays

The **Primary Displays** are for viewing only and cannot be configured. **Primary Displays** include displayed values for flow rate, totalizers, velocity, signal strength, or low signal cutoff (menus 00 through 04).

4.6.1 Flow/Net Totalizer (00)

The **Flow/Net Totalizer** is the standard display used under normal operating conditions. It displays the flow rate and net totalizer value. If the net totalizer is not currently enabled, the last net totalized value is displayed. (Figure 4.6-A)

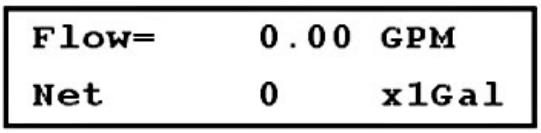


FIGURE 4.6-A

4.6.2 Flow/Velocity (01)

The **Flow/Velocity** display indicates the flow rate and fluid velocity. Velocity is displayed in feet per second (*FPS*) if ENGLISH is selected as the measurement unit in Menu 42 and in meters per second (*MPS*) if METRIC is selected. (Figure 4.6-B)

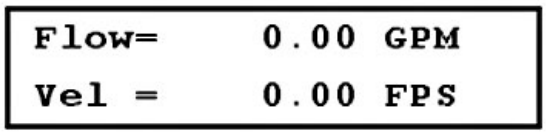


FIGURE 4.6-B

4.6.3 Flow/Positive Totalizer (02)

This display indicates the flow rate and the totalized flow in the positive flow direction. If the positive totalizer is not currently enabled, the last *net* totalized value is displayed. (Figure 4.6-C)

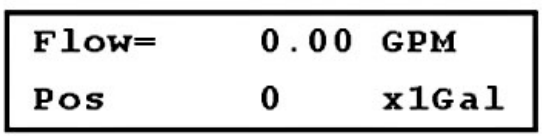


FIGURE 4.6-C

...4.6 Primary Displays continued

4.6.4 Flow/Negative Totalizer (03)

This display indicates the flow rate and the totalized flow in the negative flow direction. If the negative totalizer is not currently enabled, the last *net* totalized value is displayed. (Figure 4.6-D)

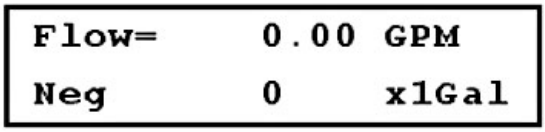


FIGURE 4.6-D

4.6.5 Signal Strength/Low Signal Cutoff (04)

This display indicates the values for signal strength and low signal cutoff. (Figure 4.6-E)

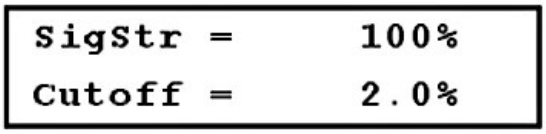


FIGURE 4.6-E

4.7 Additional Setup Menus Within the PIPE Submenu*

***Not included in the Quick Setup Configuration**

Following are **setup** menus not included in the Quick Setup Configuration detailed in Section 4.5 (page 14). **Setup** menus are used primarily to enter configuration data or to view the flowmeter's current configuration settings. The following setup menus are located within the **PIPE** submenu and are not required entries in the Quick Setup Configuration:

- **Pipe Wall Thickness** setup menu (11) (Figure 4.7-A)
- **Pipe Sound Speed** setup menu (14): This menu can only be configured if **OTHER** was selected as the pipe material in Menu 13. Enter the pipe sound speed. If **OTHER** was NOT selected as the pipe material, this menu is available by the direct access method only and functions as a view-only display to indicate the pipe sound speed as programmed in the flowmeter's database. (Figure 4.7-B)
- **Pipe Inside Roughness** setup menu (15): This menu can only be configured if **OTHER** was selected as the pipe material in Menu 13. Data on this parameter are available from the *Cameron Hydraulic Data Book* published by Ingersoll-Rand. Enter the inside roughness of the pipe. If **OTHER** was NOT selected as the pipe material, this menu is available by the direct access method only and functions as a view-only display to indicate the pipe inside roughness as programmed in the flowmeter's database. (Figure 4.7-C)

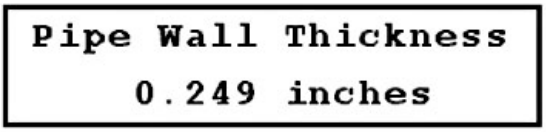


FIGURE 4.7-A

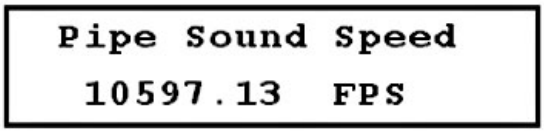


FIGURE 4.7-B

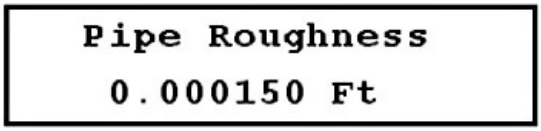


FIGURE 4.7-C

4.8 Additional Setup Menus Within the LINER Submenu*

***Not included in the Quick Setup Configuration**

- **Liner Sound Speed** setup menu (18): This menu can only be configured if **OTHER** was selected as the liner material in Menu 16. Enter the liner sound speed. If **OTHER** was NOT selected as the liner material, this menu is available by the direct access method only and functions as a view-only display to indicate the liner's sound speed as programmed in the flowmeter's database. (Figure 4.8-A)

FIGURE 4.8-A

- **Liner Inside Roughness** setup menu (18): This menu can only be configured if **OTHER** was selected as the liner material in Menu 16. Enter the liner inside roughness. If **OTHER** was NOT selected as the liner material, this menu is available by the direct access method only and functions as a view-only display to indicate the inside roughness of the liner as programmed in the flowmeter's database. (Figure 4.8-B)

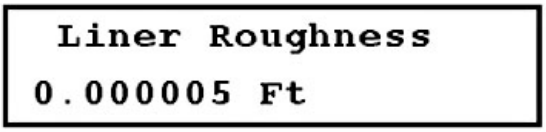


FIGURE 4.8-B

4.9 Additional Setup Menus Within the FLUID Submenu*

***Not included in the Quick Setup Configuration**

- **Fluid Sound Speed** setup menu (21): This menu can only be configured if **OTHER** was selected as the fluid type in Menu 20. Enter the fluid sound speed. If **OTHER** was NOT selected as the fluid type, this menu is available by the direct access method only and functions as a view-only display to indicate the fluid sound speed as programmed in the flowmeter's database. (Figure 4.9-A)

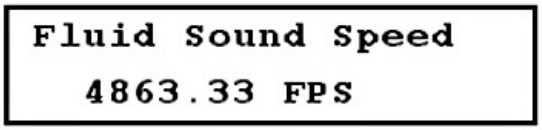


FIGURE 4.9-A

- **Fluid Viscosity** setup menu (22): This menu can only be configured if **OTHER** was selected as the fluid type in Menu 20. Enter the fluid viscosity. If **OTHER** was NOT selected as the fluid type, this menu is available by the direct access method only and functions as a view-only display to indicate the fluid viscosity as programmed in the flowmeter's database. (Figure 4.9-B)

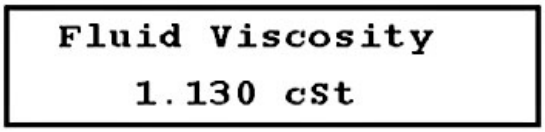


FIGURE 4.9-B

4.10 Additional Setup Menus Within the FLOW Submenu*

***Not included in the Quick Setup Configuration**

- **Max Flow Range** setup menu (31) and **Min Flow Range** setup menu (32): Use these menus to enter the minimum and maximum flow values for setting the volumetric flow range. Setting the optimum flow range generally improves the flowmeter's response time. (Figures 4.10-A and 4.10-B)

  NOTE: Whenever the pipe ID is changed, the flowmeter returns the volumetric flow range to its default settings. The default settings are the minimum and maximum flows for the new pipe ID that occur at +32 and -32 ft/s (+9.76 and -9.76 m/s).

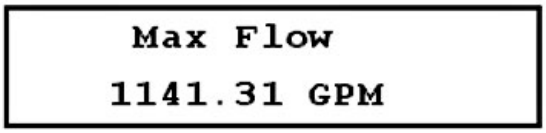


FIGURE 4.10-A

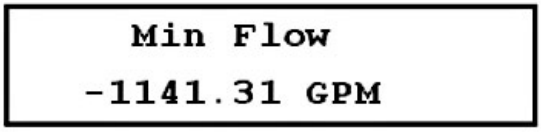


FIGURE 4.10-B

- **Damping** setup menu (33): Use this menu to enter the value for the damping coefficient, which suppresses short-term fluctuations in the indicated flow rate. The displayed flow rate and the 4-20 mA current loop output is a moving average of the last *n* seconds where *n* is the damping value. Increasing the coefficient increases the response time to changes. The coefficient is adjustable from 1 to 99 seconds in 1-second increments. Damping should be kept at a minimum unless the flow rate fluctuates wildly. If this is the case, increase the damping coefficient just enough to reduce the fluctuation to an acceptable degree. (Figure 4.10-C)

FIGURE 4.10-C

- **Low Flow Cutoff** setup menu (34): When a zero flow condition occurs (for example, as the result of a pump being shut off), internal sloshing, check valve leakage, and other fluid movement can prevent the flowmeter from reading total zero. This phenomenon can result in totalizer errors. Minimize these errors by entering a low flow cutoff, which drives the flowmeter to zero for flow rates at or below the specified value. If the flow rate falls below the low flow cutoff value, the indicated flow rate is driven to zero and the totalizers stop incrementing; this is the case regardless of flow direction. (Figure 4.10-D)

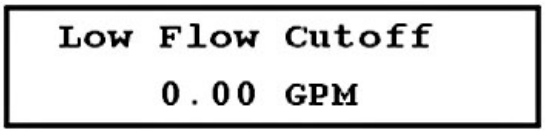


FIGURE 4.10-D

  For example, if you enter a low flow cutoff of 0.1 ft/s (.03 m/s), the flowmeter is driven to zero for flow rates less than 0.1 ft/s in the positive direction and greater than -0.1 ft/s in the negative direction. (Figure 4.10-E)

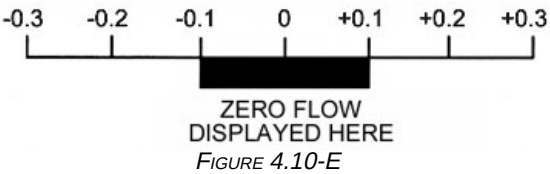


FIGURE 4.10-E

4.10 Additional Setup Menus Within the FLOW Submenu* continued

***Not included in the Quick Setup Configuration**

- **Low Signal Cutoff** setup menu (35): Empty pipes or solids, bubbles, or voids in the flow stream may cause temporary drops in signal strength and erroneous readings. Minimize the effect of these dropouts by setting a low signal cutoff, which drives the flowmeter to the loss-of-signal (LOS) condition. The low signal cutoff should be set at the minimum acceptable signal amplitude.

  To set the low signal cutoff:

  a. Access the **Low Signal Cutoff** setup menu (35). (Figure 4.10-F)

  b. Enter the low signal cutoff and press **ENTER.**

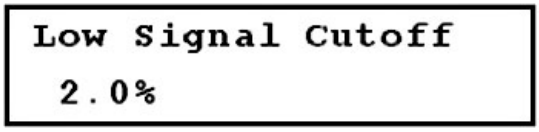


FIGURE 4.10-F

  NOTE: The value for the low signal cutoff should usually be set at approximately one-half of the value of the signal strength present under flow conditions. Typically, signal strength is not significantly affected by flow rate.

  c. Select one of the following:

  - **ZERO**: the flowmeter drops the reading to zero during LOS condition; or
  - **HOLD**: the flowmeter holds the last valid reading during LOS condition for about 3 seconds. (Figure 4.10-G)

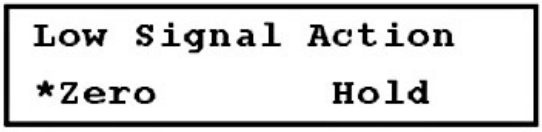


FIGURE 4.10-G

4.11 Additional Setup Menus Within the TOTAL Submenu*

***Not included in the Quick Setup Configuration**

- **Totalizer Units** setup menu (36): The flow unit selected for the totalizer display may be different from the flow unit selected for the flow rate display. (Figure 4.11-A)

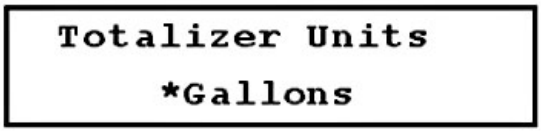


FIGURE 4.11-A

- **Totalizer Multiplier** setup menu (37): The totalizer value can be displayed with one of several multiplier values. For example, 700 liters can be displayed as *700* if the selected multiplier value is *X1*, or it can be displayed as *7* if selected multiplier value is *X100.* (Figure 4.11-B)

FIGURE 4.11-B

- **Net Totalizer** setup menu (38): Use this menu to enable or disable the net totalizer. The net totalizer provides the difference between the positive and negative flow values. For example, if there are 1000 gallons of flow in the negative direction and 3000 gallons of flow in the positive direction, the net totalizer indicates 2000 gallons of net flow. (Figure 4.11-C)

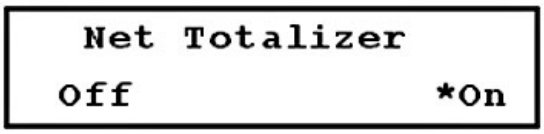


FIGURE 4.11-C

...4.11 Additional Setup Menus Within the TOTAL Submenu* continued

***Not included in the Quick Setup Configuration**

- **Positive Totalizer** setup menu (39): Use this menu to enable or disable the positive totalizer. The positive totalizer tracks the flow that moves in the positive direction, from upstream transducer to downstream transducer. It is NOT affected by flow in the opposite direction. (Figure 4.11-D)

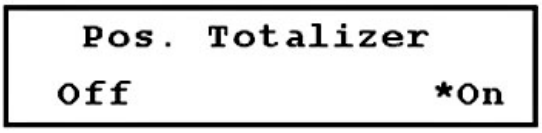


FIGURE 4.11-D

- **Negative Totalizer** setup menu (40): Use this menu to enable or disable the negative totalizer. The negative totalizer tracks the flow that moves in the negative direction, from downstream transducer to upstream transducer. It is NOT affected by flow in the opposite direction. (Figure 4.11-E)

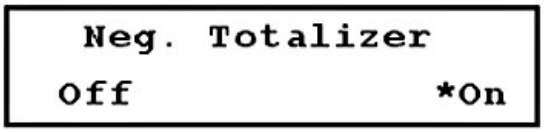


FIGURE 4.11-E

- **Totalizer Reset** setup menu (41): Use this menu to reset one or all of the totalizers. (Figure 4.11-F)

FIGURE 4.11-F

4.12 Additional Setup Menus Within the OPTIONS Submenu*

***Not included in the Quick Setup Configuration**

The **OPTIONS** submenu contains setup menus for several miscellaneous functions.

- **Measurement Units** setup menu (42): Use this menu to select **ENGLISH** (feet per second, *FPS*) or **METRIC** (meters per second, *MPS*) measurement units. (Figure 4.12-A)

FIGURE 4.12-A

- **Site Parameters** setup menu (43): This menu saves the parameters for the pipe, liner, fluid, transducer, and flow setup menus, allowing them to be recalled later for a specific measurement site. Several sites are available and are numbered. The site number is displayed in Menu 43 in the lower left corner of the screen and is followed by a colon. See Figure 4.12-B for an example of a site numbered 1.

FIGURE 4.12-B

As the setup parameters are entered in their respective menus during normal configuration, the same parameters are saved simultaneously in the **Site Parameters** setup menu, in whichever site has the asterisk displayed.

Access a different site to automatically enter that site's stored parameters into the flowmeter for measuring flow. To access a different site, press **ENTER**, scroll to the desired site, and press **ENTER** again. **To avoid overwriting stored parameters and losing old data, ensure that the desired site is active prior to entering the new set of parameters.**

...4.12 Additional Setup Menus Within the OPTIONS Submenu* continued

***Not included in the Quick Setup Configuration**

- **RS232 Configuration** setup menu (46): Use this menu to configure the RS232 port which allows the flowmeter to connect to an IBM®-compatible PC using the UltraScan (refer to the UltraScan manual) or D-Link (refer to Appendix C, page 75) utilities. (Figure 4.12-C)

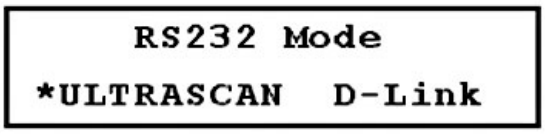


FIGURE 4.12-C

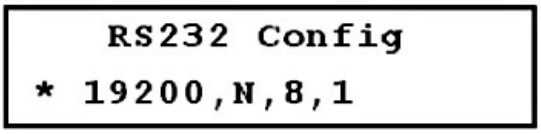


FIGURE 4.12-D

  a. Access the **RS232 Configuration** setup menu (46).

  b. Select **ULTRASCAN** or **D-LINK**.

  c. Press the **DOWN ARROW** to display the baud rate selections. The baud rate is the only RS232 parameter that can be selected. The remaining parameters (parity, character size, stop bits) are preset. (Figure 4.12-D)

  d. Access Menu 00.

- **Change System Password** setup menu (47): The flowmeter is shipped from the factory with the system password *disabled.* If a password is enabled, the flowmeter requests the password when a user attempts to enter any configuration data. Entering the correct password temporarily unlocks the system, allowing the user to make configuration changes.

FIGURE 4.12-E

FIGURE 4.12-F

  To change or disable the system password:

  a. Access Menu 47. (Figure 4.12-E)

  b. Enter the new system password and press **ENTER.** (Figure 4.12-F)

  NOTE: Disable the system password function by entering **0** (zero) as the system password. Enable the function by changing the password back to a non-zero number.

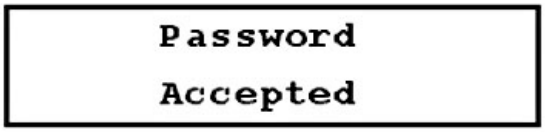


FIGURE 4.12-G

  c. Enter the old system password and press **ENTER.** If the old system password is correctly entered, Figure 4.12-G is displayed. If the pass word is incorrectly entered, Figure 4.12-H is displayed.

FIGURE 4.12-H

  NOTE: After the system password is accepted or rejected, Menu 48 is displayed, enabling the scale factor password to be changed.

  d. Access Menu 00 to lock the system with the new password.

...4.12 Additional Setup Menus Within the OPTIONS Submenu* continued

***Not included in the Quick Setup Configuration**

- **Change Scale Factor Password** setup menu (48): Use this menu to change the scale factor password which is designed to protect the scale factor from unauthorized or accidental changes. The flowmeter ships from the factor with the scale factor password *disabled.* If the scale factor password is *enabled,* the flowmeter requests the password whenever a user attempts to change the scale factor.

  To change or disable the scale factor password:

  a. Access Menu 48. (Figure 4.12-I)

  b. Enter the new scale factor password and press **ENTER.** (Figure 4.12-J)

  NOTE: The system password function must be *disabled* to allow the scale factor to be changed without entering a password.

  c. Enter the old scale factor password and press **ENTER.** If entered correctly, Figure 4.12-K is displayed. If entered incorrectly, Figure 4.12-L is displayed.

  d. Access Menu 00.

- **Unit ID (identification) Number** setup menu (49): This number is determined by the operator to identify the specific instrument or site. Any whole number between 1 and 60,000 may be entered. (Figure 4.12-M)

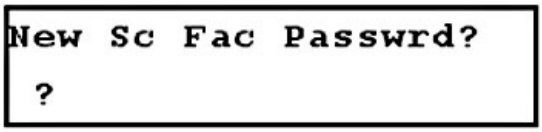


FIGURE 4.12-I

FIGURE 4.12-J

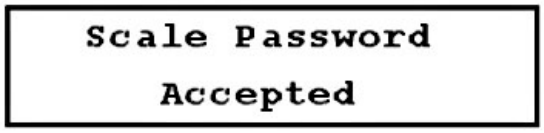


FIGURE 4.12-K

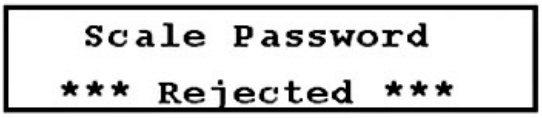


FIGURE 4.12-L

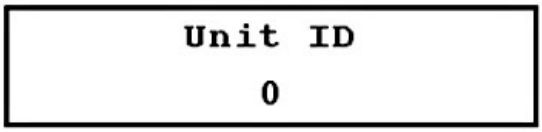


FIGURE 4.12-M

4.13 Additional Setup Menus Within the CALIBR Submenu*

***Not included in the Quick Setup Configuration**

Within the **CALIBR** submenu is the **Calibration Group** menu (50) (Figure 4.13-A), which contains 4 setup menus: **Zero Set, Scale, SS Comp, Date** (Menus 51 through 54).

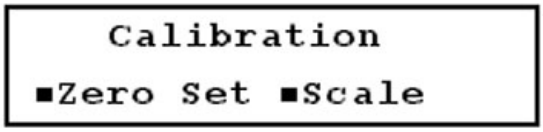


FIGURE 4.13-A

4.13.1 Zero Set Calibration

An important step in assuring accurate flow measurement is the proper calibration of the instrument and the installation. The calibration methods must be performed for the particular pipe that is to be metered. Table 3 (below) provides guidelines for selecting a calibration method.

Calibration Method	Function	Application
Zero set calibration		
Zero flow set	Zeroes the instrument for an actual no flow condition	Installations where flow can be stopped
Manual zero set	Applies a manually entered offset to all flow readings	Where an offset is required
Scale factor	Compensates for manufacturing variations in the transducers	Set by the factory to the value imprinted on the transducers

TABLE 3

After installing the meter, you may find that a small adjustment to the zero point (zero set calibration) is required. Zero set calibration allows the meter to read very close to zero under zero flow conditions. There are 2 zero set calibration methods in Menu 51: the zero flow set method and the manual zero set method. View the zero point used by the flowmeter in either of these methods by selecting **Manual** in Menu 51.

After the instrument is properly zeroed, it should display a stable reading well below 0.05 ft/s (0.015 m/s) under zero flow conditions with the low flow cutoff disabled.

Prior to performing a zero set calibration, verify the following:

- transducers are connected to the pipe;
- instrument is reading flow;
- low flow cutoff is disabled to allow verification of calibration.

4.13.1.a Zero Flow Set Method

The best method of zeroing the instrument is to stop the flow and perform a zero flow set on the pipe. The purpose of the zero flow set is to zero the instrument for the individual application. This method is used *only* when flow in the pipe can be stopped. The flow rate displayed in Menu 01 must be between -0.25 and +0.25 ft/s (-0.076 and +0.076 m/s).

1. Ensure there is no flow in the pipe.
2. Access Menu 51. (Figure 4.13-B)
3. Select **No Flow.** If the zero flow set calibration is successful, Figure 4.13-C is displayed. If the flow rate is too high to perform a zero flow set calibration, Figure 4.13-D is displayed; continue to step 4.
4. If Figure 4.13-D is displayed, press any key and repeat step 1 through 3 when the flow rate is within required limits.

FIGURE 4.13-B

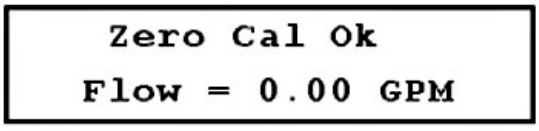


FIGURE 4.13-C

FIGURE 4.13-D

4.13.1.b Manual Zero Set

Use this method infrequently. Manual zero set applies a constant offset entered by the user to all readings. For example, if the flow reads 250 GPM and a 10 GPM offset is applied, the new reading becomes 240 GPM.

To zero the instrument using the manual zero set method:

1. Ensure that the minimum flow range setting in Menu 32 is the negative equivalent of the maximum flow rate setting in Menu 31.

2. Enter **0.00** as the manual zero setting in Menu 51, then access Menu 00.

3. Minimize flow occurring in the pipe.

4. Set the damping so that the flowmeter reads a steady flow.

5. Allow the flowmeter to settle for 10 minutes.

6. Take 10 separate flow readings and average. This average is designated as **P** for positive in the formula seen in step 10.

7. Disconnect the transducer wires, and reverse the upstream and downstream wires. The flowmeter displays a negative flow reading.

8. Allow the meter to settle for 10 minutes.

9. Take another 10 readings and average. This value is designated as **N** for negative in the formula in step 10.

10. Determine the manual zero point (**Zp**) by performing the following calculation:

$$Z_p = \frac{(P+N)}{2}$$

11. Access Menu 51 and select **Manual.**

12. Enter the zero point in Menu 51. If necessary, you can apply a negative offset by pressing **±** (plus/minus key).

13. Press **ENTER**, and access Menu 00. Reconnect the transducer wires according to their original orientation.

14. Restore the minimum and maximum flow range values (menus 31 and 32) if they were changed.

15. Allow the flowmeter readings to settle for 10 minutes.

4.13.2 Scale Factor Calibration

After setting and verifying the instrument's zero point, you can set a scale factor to adjust the measured flow; the measured flow is multiplied by this scale factor. For example, if the displayed flow is twice the actual flow, you can enter a scale factor of 0.5 to divide the displayed flow by 2. The primary reason for setting the scale factor is to compensate for manufacturing variations in the transducers. The scale factor printed on the transducer set should be entered in Menu 52.

...4.13.2 Scale Factor Calibration continued

Observe the following precautions when setting the scale factor:

- Always determine the scale factor at the highest possible flow rate achievable in order to maximize accuracy of the scale factor.
- Use only the factory preset scale factor as marked on the transducers in the following situations: the flow cannot be stopped to verify or set the zero point; a reasonably high flow rate cannot be achieved; an accurate secondary flow standard is not available.

If an additional scale factor is required, the additional scale factor should be multiplied by the factory scale factor and the result should be entered. To enter a new scale factor:

1. Access Menu 52. (Figure 4.13-E)
2. Enter the new scale factor and press **ENTER.** Figure 4.13-F is displayed.
3. Enter the valid password and press **ENTER.**

   The new scale factor is displayed in Menu 52. To maximize security, enter a new scale factor password immediately.

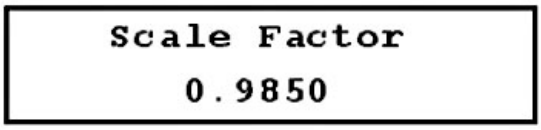


FIGURE 4.13-E

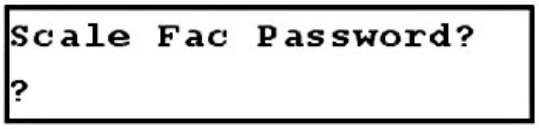


FIGURE 4.13-F

4.13.3 Other CALIBR Submenu Options

- **Sound Speed Compensation** setup menu (53): Enable or disable the flowmeter's sound speed compensation. Temperature variations in the fluid and other factors may cause variations in the fluid's sound speed. Typically, the flowmeter can determine sound speed more accurately when this feature is enabled. (Figure 4.13-G)

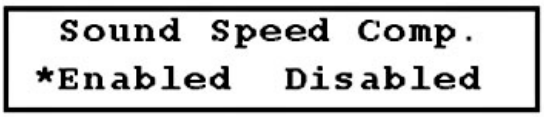


FIGURE 4.13-G

- **Date and Time** setup menu (54): Use this menu to set the date and time in the flowmeter's internal clock. The time is expressed in military time (24-hour format), and the date is in the month-day-year format (Figure 4.13-H). If you are NOT using UltraScan, set the time and date as follows:

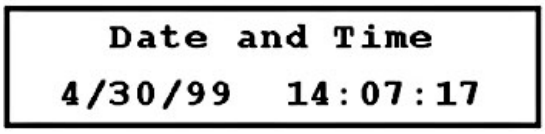


FIGURE 4.13-H

   a. Perform a Master Erase on the flowmeter according to Section 7.2 (page 43).

   b. Reconfigure the flowmeter, and access Menu 54.

   NOTE: Performing a Master Erase and reconfiguring the flowmeter prior to changing date or time prevents possible data corruption.

   c. Press **ENTER**, and prompts are displayed, requesting entries for month, day, year and hour, minute, second (Figure 4.13-I). Press **ENTER** after EACH entry.

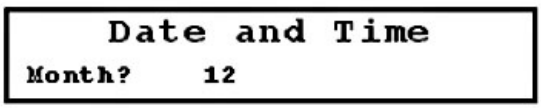


FIGURE 4.13-I

...4.13.3 Other CALIBR Submenu Options continued

- **Date and Time** setup menu (54) continued

  d. To keep the current values displayed in any screen, scroll to the next screen with the **DOWN ARROW** instead of pressing **ENTER.**

  e. Once all parameters are entered, the new programmed date and time is displayed.

4.14 Additional Setup Menus Within the 4-20mA Submenu*

***Not included in the Quick Setup Configuration**

Within the **4-20mA** submenu is the **Current Loop Grou** menu (56), which contains 3 setup menus: **Span, Cal., Test** (menus 57 through 59). (Figure 4.14-A)

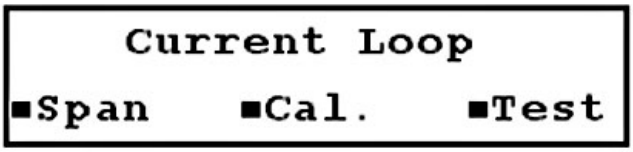


FIGURE 4.14-A

The 4-20 mA current loop is factory calibrated and should not require field calibration prior to use. If calibration and testing should become necessary, complete the following steps:

1. Connect a milliammeter to the input (*IN*) and output (*OUT*) terminals of the current loop module.
2. Access Menu 58. (Figure 4.14-B)
3. Press the **RIGHT** or **LEFT ARROWS** to adjust the 4 mA set point until the value reads exactly 4.00 mA on the milliammeter. Every 2 presses of the arrow key adjusts the calibration approximately .01 mA.
4. Press **ENTER**.
5. Access Menu 58 again.
6. Press the **DOWN ARROW** to scroll to the **20 mA Calibrate** screen. (Figure 4.14-C)
7. Repeat step 3 for entering the 20 mA set point.
8. Access Menu 00.
9. *Test* the current loop calibration by accessing Menu 59. (Figure 4.14-D)

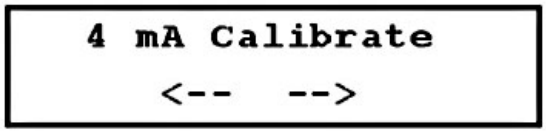


FIGURE 4.14-B

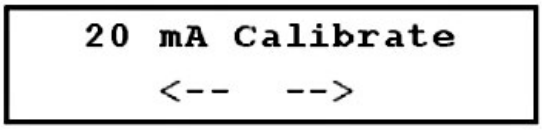


FIGURE 4.14-C

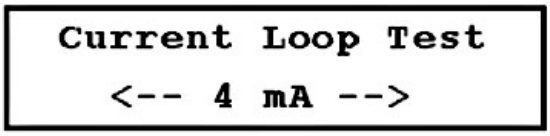


FIGURE 4.14-D

10. Change the current loop output in 1 mA increments using the **RIGHT** or **LEFT ARROWS**. The output indicated on the screen should be the same as the output on the milliammeter. If the values do not match, repeat steps 2 through 10.

...4.14 Additional Setup Menus Within the 4-20mA Submenu* continued

***Not included in the Quick Setup Configuration**

11. Set the current loop *span* by accessing Menu 57 (Figure 4.14-E). The current loop span is the span of flow versus current.
12. Enter a flow rate which equals the 4 mA (minimum anticipated) reading, and press **ENTER.**
13. Press the **DOWN ARROW**, and Figure 4.14-F is displayed.
14. Enter a flow rate which equals the 20 mA (maximum anticipated) reading, and press **ENTER.**
15. Access Menu 00 to complete the current loop calibration process.

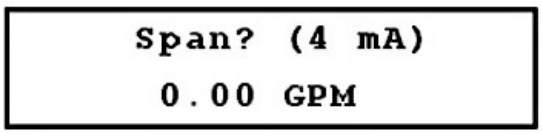


FIGURE 4.14-E

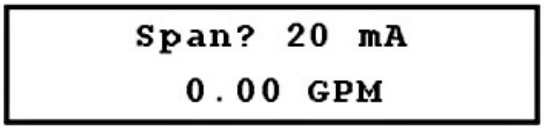


FIGURE 4.14-F

NOTE: The current loop output freezes for approximately 30 seconds after calibrating or testing.

4.15 Additional Setup Menus Within the RELAYS Submenu

Refer to Section 5 (page 30) for information on the **RELAYS** submenu (70).

4.16 Additional Setup Menus Within the DATA LOG Submenu*

***Not included in the Quick Setup Configuration**

The **DATA LOG** submenu contains the **Log Menu** (80) and the **Log Interval** menu (81). The datalogger provides the ability of continuously recording flow data at a preset interval. The flowmeter has a single datalog file with approximately 30,000 data points available. This allows considerable data to be collected. For instance, if collecting data at a 60-second interval, the flowmeter could store data for approximately 20 days. The datalogger is always enabled (always recording data). When all 30,000 points are recorded, the datalogger records over the previous data points one at a time in a continuous loop, starting with the oldest data points first.

The log file can be transferred in ASCII format to an IBM®-compatible PC for record keeping or analysis. In addition, the datalog file can be deleted by resetting the data point values to zero. Log files are transferred using the D-Link flowmeter data link utility (Appendix D, page 75).

- **Data Log Setup** menu (80): The only option available in this menu is **Interval** (Figure 4.16-A). Select this to access menu 81.
- **Data Log Interval** menu (81): Datalog intervals must be entered in whole seconds, with a minimum interval of 1 second. (Figure 4.16-B)

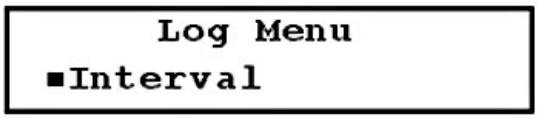


FIGURE 4.16-A

FIGURE 4.16-B

...4.16 Additional Setup Menus Within the DATA LOG Submenu* continued

***Not included in the Quick Setup Configuration**

The datalogger automatically deletes data whenever the log interval, data, time, flow units, pipe dimensions, or liner dimensions are changed.

Any power interruptions cause zeroes to be written in the datalog stream. This feature is useful to determine if an interruption in the time sequence has occurred or if the instrument has been moved or tampered with while logging data.

4.17 Additional Setup Menus Within DIAGNOSTICS Submenu*

***Not included in the Quick Setup Configuration**

The **DIAGNOSTICS** submenu contains various view-only menus which display important diagnostic parameters that are currently used or calculated by the flowmeter. These parameters are helpful when configuring or troubleshooting the flowmeter.

- **Signal Strength/Margin** display (90): Displays the signal strength in percentage and the margin. The signal strength value displayed is the average of the signal strengths for the upstream and downstream transducers. Margin is an indicator of signal quality and is generally greater than 50%. Signal strength is generally greater than 3% under good measurement conditions. (Figure 4.17-A)
- **Delta Time/Fluid Sound Speed** display (91): Displays the value for DeltaT and the fluid sound speed as measured by the flowmeter. DeltaT is the difference between the upstream and downstream travel times, expressed in nanoseconds (ns). (Figure 4.17-B)
- **Reynolds Number/Profile Factor** display (92): Displays the Reynolds number and flow profile factor currently being used by the flowmeter. The flow profile factor is calculated by the flowmeter and used to determine the effect of the flow profile on mean measured fluid velocity. (Figure 4.17-C)
- **Current Loop Output** display (93): Displays values of the current in mA that the flowmeter is presently providing to the current loop output. (Figure 4.17-D)
- **Software/Firmware Revision Level** display (94): Displays the software (*SOFT VERS.*) and firmware (*FPGA VERS.*) versions installed in the flowmeter. (Figure 4.17-E)

FIGURE 4.17-A

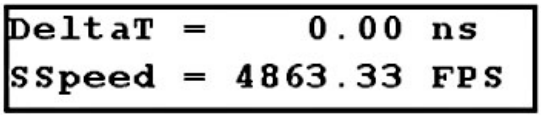


FIGURE 4.17-B

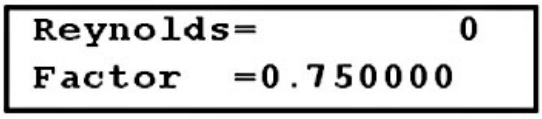


FIGURE 4.17-C

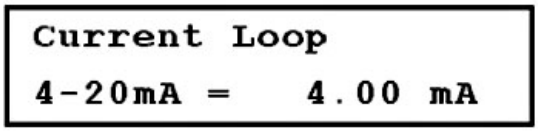


FIGURE 4.17-D

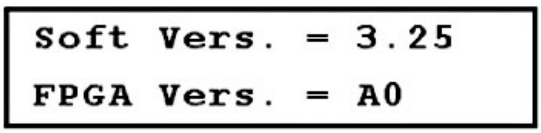


FIGURE 4.17-E

5. THE RELAYS SUBMENU

The **RELAYS** submenu (Figure 5) contains the setup menus for programming, viewing, and testing the flowmeter's relay parameters. The relays may be used for functions such as alarm, pump control, etc. Up to 4 relays may be independently programmed for a variety of ON and OFF conditions. Alternatively, the relay can send a pulse to a remote device (for example, a totalizer, sampler, or chlorinator) whenever the internal totalizer advances by one unit.

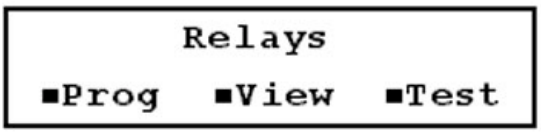
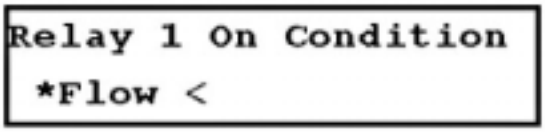


*FIGURE 5: **RELAYS** SUBMENU*

5.1 Programming the Relay

1. Access Menu 71. (Figure 5.1-A)

2. Each relay is independently programmed; select the relay you want to program. The *Relay On Condition* screen is displayed. (Figure 5.1-B)



FIGURES 5.1-A & 5.1-B

3. Select one of the following relay ON conditions:

- **NOT PROGRAMMED (OFF)**;
- **FLOW >** : relay actuates when the flow rate is greater than the ON condition value;
- **FLOW <** : relay actuates when the flow rate is less than the ON condition value;
- **SIGNAL >** : relay actuates when the signal strength value is greater than the ON condition value;
- **SIGNAL <** : relay actuates when the signal strength value is less than the ON condition value;
- **NET TOT >** : relay actuates when the net totalizer value is greater than the ON condition value;
- **NET TOT <** : relay actuates when the net totalizer value is less than the ON condition value;
- **POS TOT >** : relay actuates when the positive totalizer value is greater than the ON condition value;
- **POS TOT <** : relay actuates when the positive totalizer value is less than the ON condition value;
- **NEG TOT >** : relay actuates when the negative totalizer value is greater than the ON condition value;
- **NEG TOT <** : relay actuates when the negative totalizer value is less than the ON condition value;
- **NET TOTAL PULSE** : relay cycles once each time the net totalizer increments;
- **POS TOTAL PULSE** : relay cycles once each time the positive totalizer increments;
- **NEG TOTAL PULSE** : relay cycles once each time the negative totalizer increments.

...5.1 Programming the Relay continued

Step 3 continued:

NOTE: The output for the PULSE selections is limited to 1 cycle per second. The pulse duration (relay ON time) is approximately 500 milliseconds. If the totalizer increments more than once per second, the flowmeter tracks how far behind the relay pulses are. The flowmeter then “catches up” when a flow condition occurs where the totalizer increments at a rate of less than once per second. To prevent the relay pulse output from falling behind, the totalizer multiplier (Menu 37) should be selected so that at the maximum anticipated flow rate, the totalizer increments once per second or less. For example if the totalizer unit is gallons and the maximum anticipated flow is 600 gallons per minute (10 gallons per second), a multiplier of 10 should be selected.

NOTE: The net totalizer can either increment or decrement depending upon the direction of the flow. Since the external totalizer (driven by the net totalizer pulse) can only increment, the flowmeter stops transmitting pulses whenever negative flow is being measured. The flowmeter tracks the negative flow and does not start sending pulses to the external totalizer until the measured negative flow is canceled out by positive flow. If an application has negative flow for extended periods of time, separate external totalizers should be used, driven by the positive and negative totalizers. The net flow total can then be determined by subtracting the value for the negative external totalizer from the value for the positive external totalizer.

4. Press the **DOWN ARROW**, and the *Relay On Condition Value* screen is displayed as seen in Figure 5.1-C.

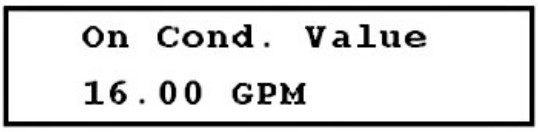


FIGURE 5.1-C

5. Enter the value for the relay ON condition. Press **ENTER.**

   NOTE: The flow units used for the relays are the same as the flow units selected for measuring flow in Menu 30.

6. Press the **DOWN ARROW**, and the *Relay Off Condition* screen is displayed. (Figure 5.1-D)

FIGURE 5.1-D

7. Select a relay OFF condition:

   The selections available for the OFF condition are the same as those for the ON condition. (If the ON condition is one of PULSE selections, an OFF condition is not applicable.) The OFF condition value should be entered in conjunction with the ON condition value to establish a “dead band”. This prevents the relay from continuously cycling on and off when the flow is close to the ON or OFF value. For example, if the ON condition is FLOW > 250 gallons per minute, the OFF condition may be set at FLOW < 240 gallons per minute. At these settings, the relay turns on when the flow exceeds 250 gallons per minute and does not turn off until the flow falls below 240 gallons per minute.

8. Press the **DOWN ARROW**, and the *Relay Off Condition Value* screen is displayed. (Figure 5.1-E)

9. Enter the value for the relay OFF condition, and press **ENTER.**

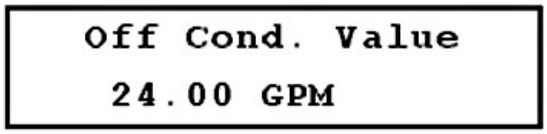
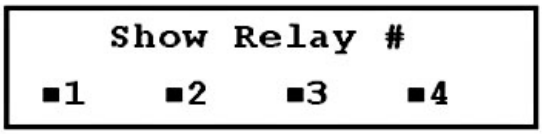


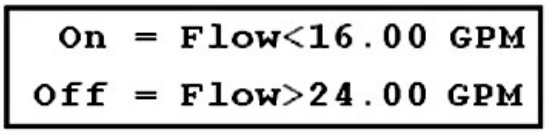
FIGURE 5.1-F

10. Repeat step 1 through 9 for each relay you want to program.

5.2 Viewing Relays

You can view the current ON and OFF conditions of the relays by accessing Menu 72 (Figure 5.2-A), and selecting the desired relay. The ON and OFF conditions for the selected relay is displayed as seen in Figure 5.2-B.





FIGURES 5.2-A & 5.2-B

5.3 Testing Relays

Relays are tested by manually turning them on and off. This is accomplished using the **Test Relays** setup menu (73). Test a relay as follows:

1. Access Menu 73. The ON/OFF status of each relay is displayed as seen in Figure 5.3. This display shows that relays 1 and 2 are off, and relays 3 and 4 are on.

FIGURE 5.3

2. Select the relay and press **ENTER.** The relay's ON or OFF indication on the display changes to indicate the new status. The relay should audibly click as it opens or closes, and the LED should light up when the relay is on.
3. Repeat steps 1 through 2 for each relay you want to test.
4. Once you have completed testing the desired relays, exit the relay test function by pressing **ERASE** or by directly accessing another menu.

6. Wiring & Installing the Transducers

6.1 Wiring

The transducer terminals and cables are arranged in pairs and are labeled *DN STREAM* and *UP STREAM*. The downstream transducer cable has blue-banded ends; the upstream transducer has red-banded ends.

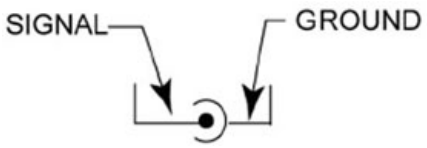


Figure 6.1

Locate the symbol seen in Figure 6.1. This symbol is on both pairs of terminals and indicate which terminals should connect to the center wire conductors and which should connect to the coaxial shields.

6.2 Site Selection & Preparation

Prior to installing the transducers, a proper site must be selected to ensure accurate measurement. Examples of site recommendations are illustrated in Figures 6.2-A (below) and 6.2-B (page 34).

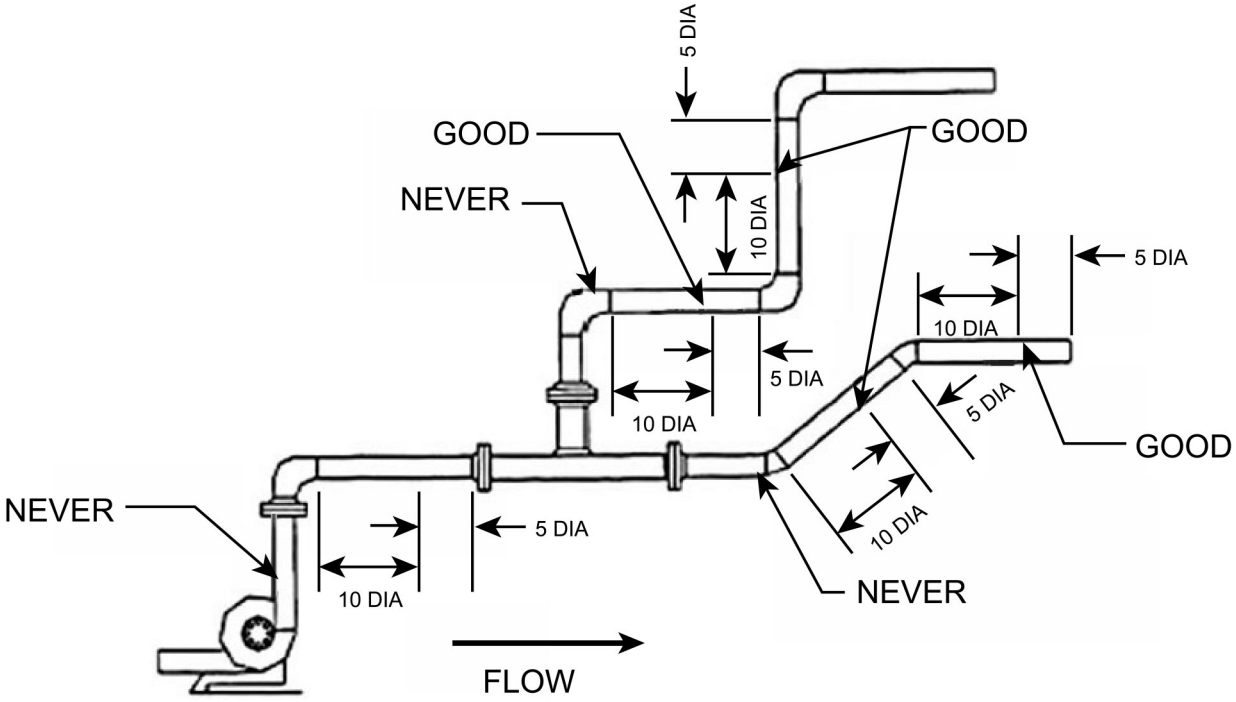


Figure 6.2-A

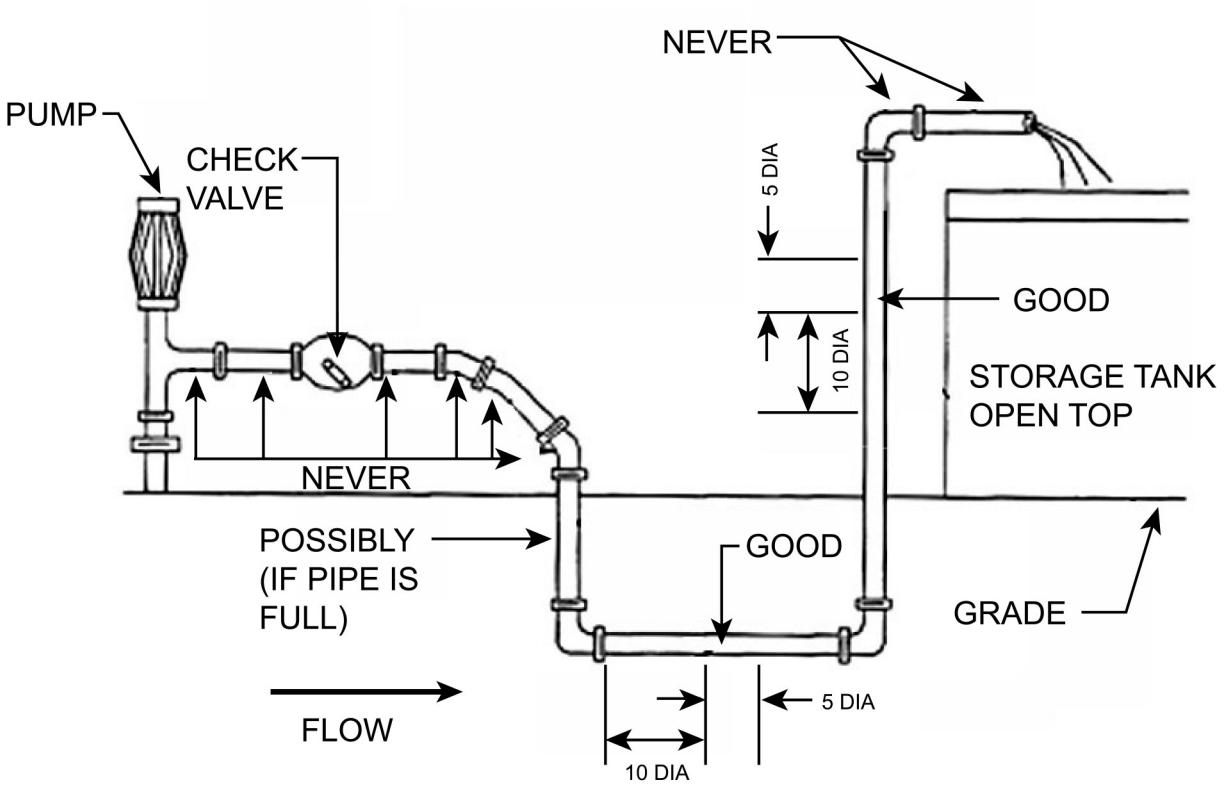


FIGURE 6.2-B

Use the following guidelines when selecting the transducer site:

- Choose a section of pipe which is always full of liquid, such as a vertical pipe with up flow or a full horizontal pipe.

- The site should have a **straight run equivalent to at least 10 pipe diameters upstream and 5 pipe diameters downstream** from any elbows, tees, throttling valves, orifices, reduced sections, or other flow disturbances.

- Up to 30 diameters of straight run may be required upstream from the flowmeter after a pump, control valve, or double piping bend for greater accuracy. A distance of 5 diameters downstream is *usually* sufficient under all circumstances.

- Always mount the transducers on the sides of the pipe in the 3 o'clock or 9 o'clock positions on horizontal pipes. Positioning the transducers in this manner prevents signal loss which can be caused by sediment along the bottom of the pipe or gas bubbles and air pockets along the top of the pipe.

- Ensure that the pipe skin temperature is within the transducer temperature rating. The transducers are rated for -40º to +212º F (-40º to +100º C). Temperature ratings up to 392º F (200º C) are available with optional high temperature transducers.

- Pipes with excessive corrosion or scaling create conditions which can make accurate measurement difficult or impossible; if possible, avoid selecting these sections of pipe as mounting locations.

- Remove any dirt, grease, rust, loose paint, or scale from the pipe surface prior to mounting the transducers. To obtain best results on aging and rough pipes, a file or grinder may be required to clean the pipe down to bare metal.

If your application cannot follow these guidelines completely, meaningful flow measurements (with some loss in accuracy and stability) may still be obtained, depending on signal quality.

6.3 Spacing & Mounting the Transducers

Once you have selected a proper transducer site, you must ensure proper transducer spacing and mounting in order to maximize signal strength and accuracy:

1. Determine which mounting method is appropriate for your application: V, W, Z, VV, WV.

2. Refer to Section 4 (page 11) to configure the flowmeter via the keypad or to the UltraScan manual to configure with UltraScan, and note the value required for the transducer spacing (value calculated by and displayed on flowmeter LCD or in UltraScan).

3. Clean the area of the pipe designated as the mounting location. Remove any rust, scale, or loose paint; well-bonded paint does not need to be removed.

On horizontal pipes, the transducers should be mounted in the 3 o'clock and 9 o'clock positions in order to avoid situations which can cause signal loss, i.e., sediment along the bottom of the pipe, gas bubbles or air pockets along the top of the pipe.

4. Apply a wide bead of sonic coupling compound lengthwise down the center of the face of each transducer.

The coupling compound should squeeze out from around the edges of the transducer when placed against the pipe. There should be no air gaps between the transducer and the pipe. Refer to Section 8.3 (page 45) for more information on applying and replacing sonic coupling compound and for information on the use of other sonic coupling compounds for high temperature, underground, or submerged installations.

5. Attach the transducers to the pipe by using the stainless steel clamps and referring to one of the following sections to mount the transducers according to the selected mounting method:

    - the V method: Section 6.4.1 (page 37),
    - the W method: Section 6.4.2 (page 37),
    - the Z method: Section 6.4.3 (page 38),
    - the VV and VW methods: Section 6.4.4 (page 41).

The transducers should be mounted on the pipe in relation to the direction of flow, as shown in Figure 6.3-A (below). Reversing the position of the upstream and downstream transducers or reversing the transducer cable connections to the instrument results in negative flow readings.

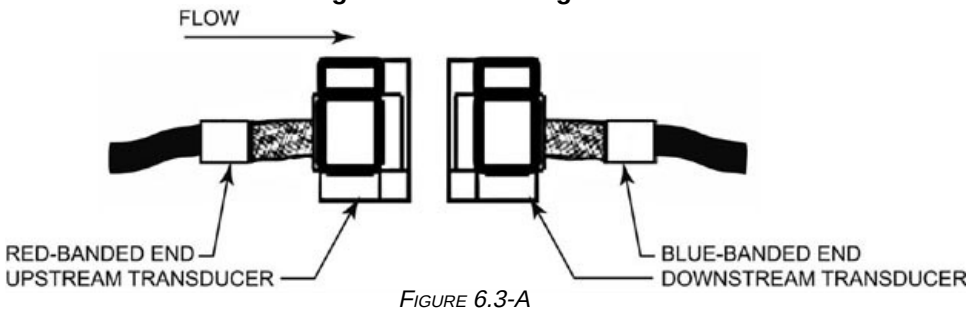


FIGURE 6.3-A

6. Tighten both straps securely. Ensure the transducer face is aligned normal to the pipe (Figure 6.3-B, below). The transducer face alignment is particularly critical on small pipes due to pipe curvature. Notice that the properly installed transducer contacts the pipe at the pipe's centerline and that the gaps on either side of the centerline are equal. Follow these steps for the easiest method of aligning transducers on small pipes:

    a. Secure both transducers to the pipe with pipe clamps, and tighten the clamps until the transducers fit snugly.

    b. Adjust the transducers until the gaps on both sides are equal.

    c. While holding the transducers in place, tighten the clamps sufficiently to prevent the transducers from slipping and to allow proper flowmeter operation.

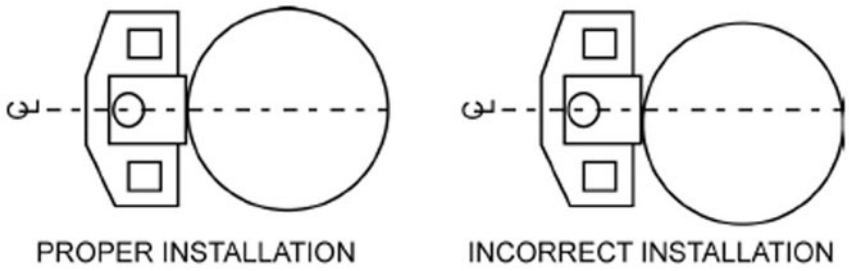


FIGURE 6.3-B

7. Connect the transducer cables to the flowmeter.

    - The transducer cables connect to the to the terminal block labeled as *TRANSDUCERS* (Figure 2.2, page 7):

        a. Connect center wire of downstream transducer cable to the ***XMT (DN)*** terminal.
        b. Connect braided shield wire of downstream transducer cable to the ***XMT GND*** terminal.
        c. Connect center wire of upstream transducer cable to the ***RCV (UP)*** terminal.
        d. Connect braided shield wire of upstream transducer cable to the ***RCV GND*** terminal.

    - The upstream transducer cable has red-banded ends, and the downstream transducer cable has blue-banded ends (Figure 6.3-A, page 35).

    Refer to Section 9 (page 49) for information on connecting the transducer cables in hazardous area applications.

8. If maximum accuracy at low flow rates is important, calibrate the flowmeter according to Section 4.13 (page 30).

    The flowmeter is now capable of accurately measuring velocity and flow.

6.4 Transducer Mounting Methods

There are several methods of mounting the transducers. The best method is determined by the specific application. Complete steps 1-5 in Section 6.3 (page 35), and refer to the following sections for instructions on how to properly mount the transducers with one of the available mounting methods.

6.4.1 V Method

The V method (Figure 6.4-A, below) is considered the standard method for pipes with 4- to 16-in (101.6 to 406.4 mm) diameters. This method typically yields a more accurate reading than the Z method since it utilizes a longer measurement path.

Ensure V is the selected mounting method.

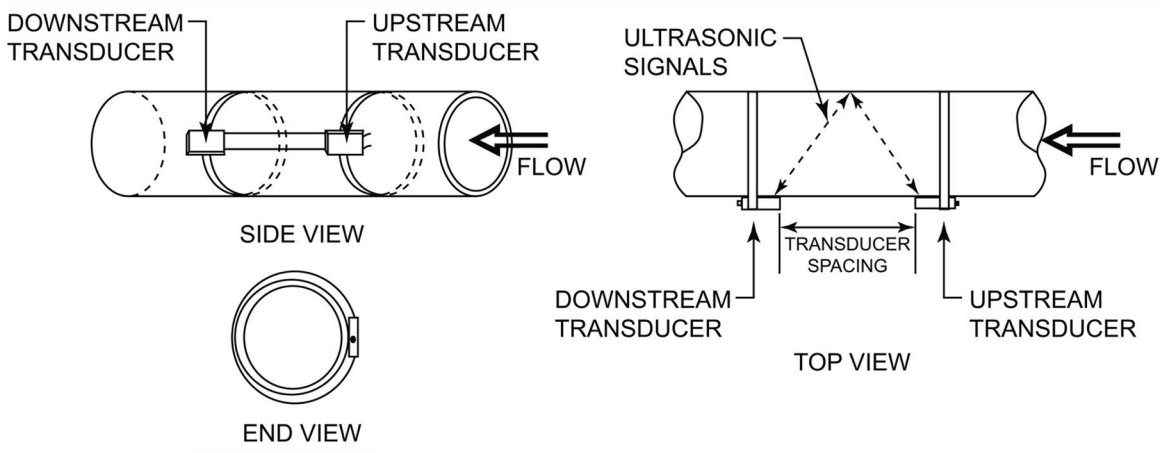


FIGURE 6.4-A: V MOUNT

6.4.2 W Method

In many instances, flowmeter performance on small metallic pipes with outer diameters of 4 inches (100 millimeters) or less can be improved by using the W mounting method (Figure 6.4-B, below). With the W method, the sound wave traverses the fluid 4 times and bounces off the pipe walls 3 times. Like the V method, both transducers are mounted on the same side of the pipe.

Ensure W is the selected mounting method.

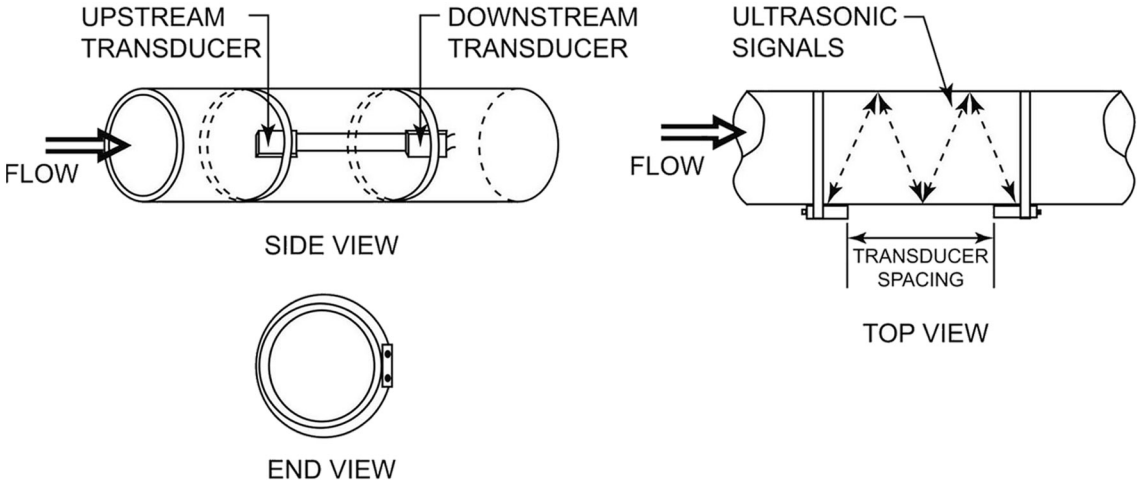


FIGURE 6.4-B: W MOUNT

6.4.3 Z Method

The signal transmitted in a Z method installation has less attenuation than a signal transmitted with the V method. This is because the Z method utilizes a directly transmitted (rather than reflected) signal which transverses the liquid only once. The Z method (Figure 6.4-C, below) is used primarily in applications where the V method cannot work due to signal attenuation from excessive air or solids in the liquid, thick scale, poorly bonded linings, or very large pipes. In addition, the Z method generally works better on larger diameter pipes where less pipe length is required for mounting.

Ensure Z is the selected mounting method.

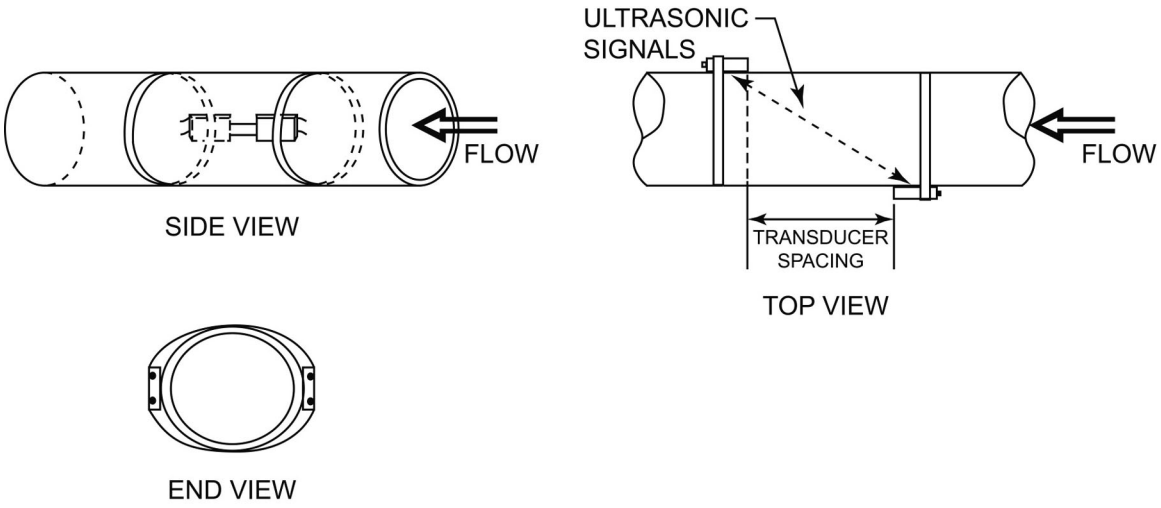


FIGURE 6.4-C: Z MOUNT

1. Establish a reference at both the 3 o'clock and 9 o'clock positions on the pipe. (Figure 6.4-D)

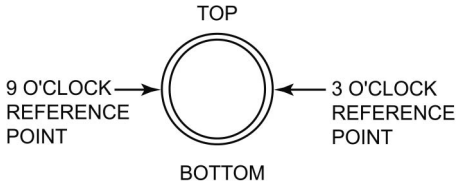


FIGURE 6.4-D: Z MOUNT, STEP 1

2. Place a transducer at the 3 o'clock position.

3. Trace the shape of the 3 o'clock transducer along its inside edge (opposite the cable connection). Draw a horizontal line at its center. Remove the transducer.

   (Figure 6.4-E)

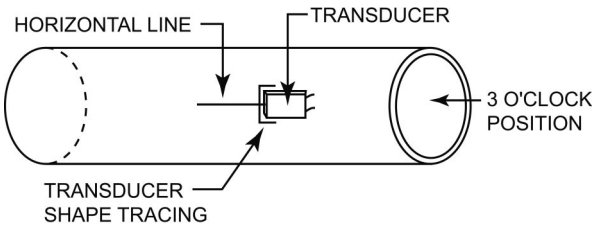


FIGURE 6.4-E: Z MOUNT, STEPS 2-3

4. Obtain a continuous sheet of paper longer than the circumference of the pipe. Calculator paper tape or thermal printer paper works well for this.

5. Fold one end of the paper across the pipe's width to produce a clean, straight edge.

6. Line the fold of the paper up with the horizontal centerline of the 3 o'clock transducer.

   (Figure 6.4-F)

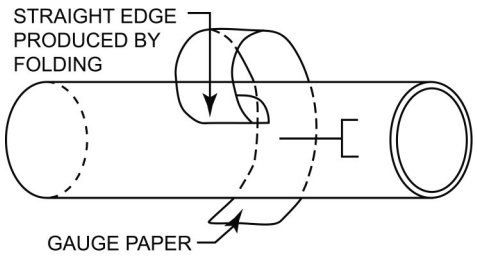


Figure 6.4-F: Z Mount, steps 4-6

7. Wrap the paper firmly around the pipe, and mark the intersection point where the fold comes in contact with the rest of the paper. (Figure 6.4-G)

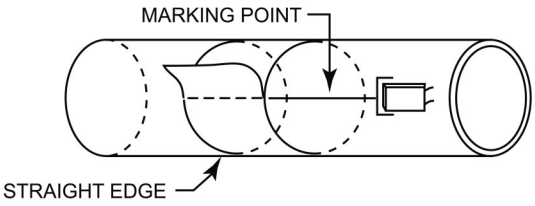


Figure 6.4-G: Z Mount, step 7

8. Remove the paper from the pipe. Place the fold and intersection mark together again, and fold the paper exactly in half. (Figure 6.4-H)

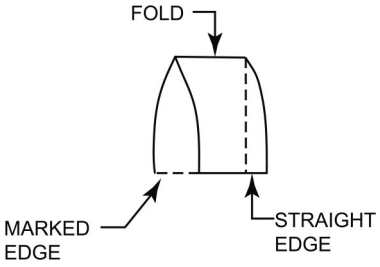


Figure 6.4-H: Z Mount, step 8

9. Mark along the new fold. (Figure 6.4-I)

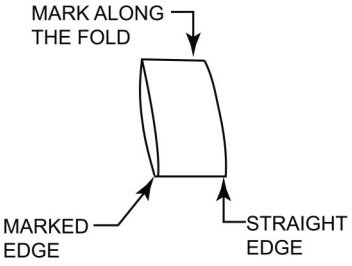


Figure 6.4-I: Z Mount, step 9

10. Draw a horizontal line along the pipe from the centerline of the 3 o'clock transducer position. Use a level to ensure that the line is level with the top of the pipe. The line should be at least 3 inches (76 millimeters) longer than the transducer spacing calculated by UltraScan or via Menu 25.

    For example, if UltraScan calculates the spacing as 14 inches (356 millimeters), draw a line 17 inches (432 millimeters) long. (Figure 6.4-J)

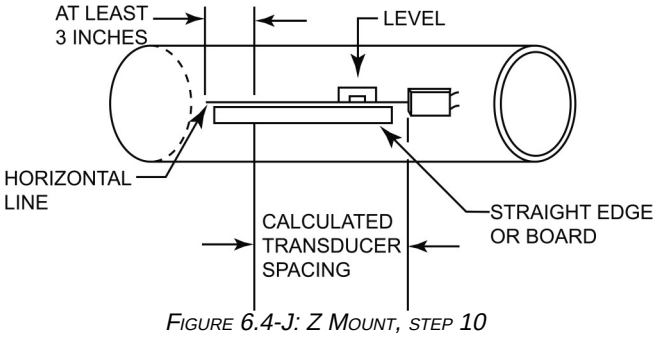


Figure 6.4-J: Z Mount, step 10

11. Measure the spacing from the inside edge of the 3 o'clock transducer, and mark this on the pipe. (Figure 6.4-K)

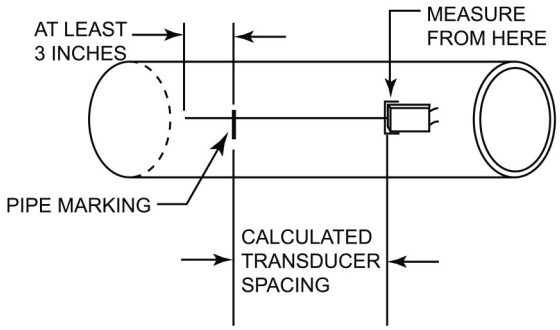


FIGURE 6.4-K: Z MOUNT, STEP 11

12. Wrap the paper firmly back on the pipe. Have the point where the ends of the paper come together line up with the horizontal line on the 3 o'clock side of the pipe. Ensure that the inside corner of the straight edge of the paper is aligned with the mark made for the transducer spacing. Tape the paper down, or have someone hold the paper in place. (Figure 6.4-L)

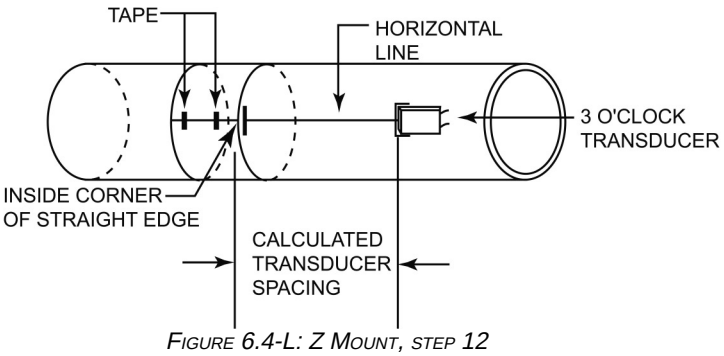


FIGURE 6.4-L: Z MOUNT, STEP 12

13. Go to the other side of the pipe (9 o'clock position), and mark the pipe at the point where the marked fold and the inside edge of the paper length intersect. (Figure 6.4-M)

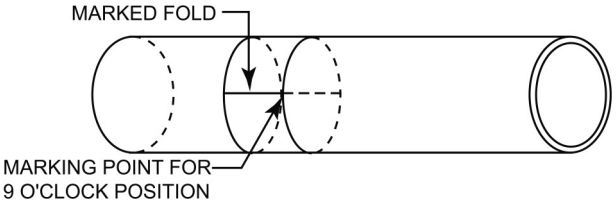


FIGURE 6.4-M: Z MOUNT, STEP 13

14. Remove the paper from the pipe and trace the shape of the 9 o'clock transducer in the same manner you did for the 3 o'clock transducer. Ensure that the inside edge of the transducer (opposite the cable connection) is even with the point just marked on the 9 o'clock side of the pipe. (Figure 6.4-N)

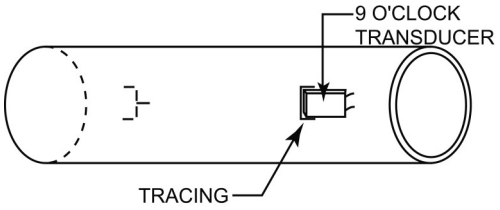


FIGURE 6.4-N: Z MOUNT, STEP 14

15. Mount the transducers with pipe straps by following steps 5-6 in Section 6.3 (page 35). (Figure 6.4-O)

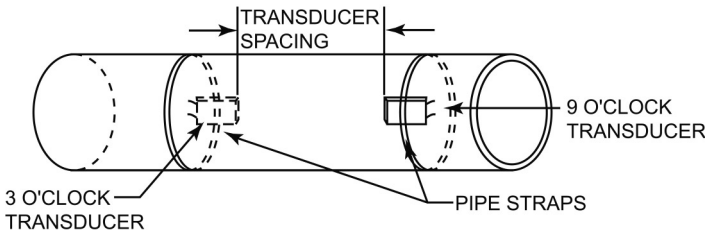


FIGURE 6.4-O: Z MOUNT, STEP 15

The figure below illustrates the final Z method installation.

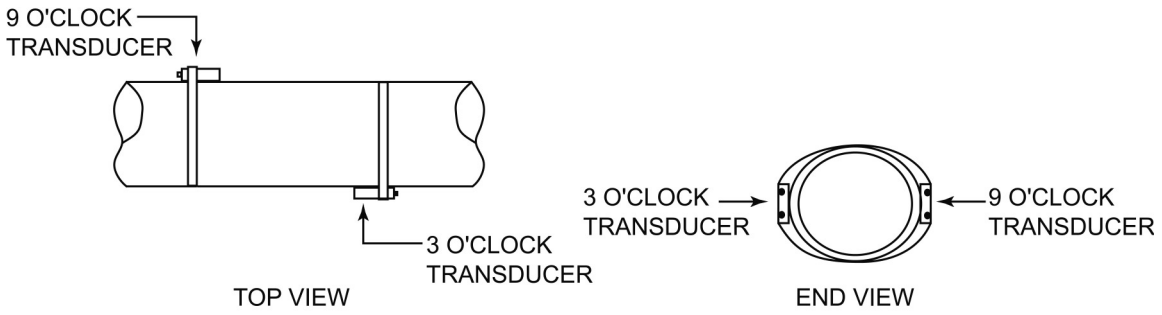


FIGURE 6.4-P

6.4.4 WV and WW Methods

For applications with pipe diameters smaller than 2 inches (50 millimeters), the WV and WW methods are options to achieve higher accuracy and stability when reasonable signal strength can be obtained (10% or higher).

6.5 Small Pipe Applications

In this section, small pipe applications refer to the following pipe sizes:

- stainless steel or brass: 1.0 to 3.5 in (25.4 to 88.9 mm)
- PVC, carbon steel, or other: 1.0 to 2.5 in (25.4 to 63.5 mm).

If signal strength is greater than 10%, we recommend the W mounting method for pipe sizes 3.5 in (63.5 mm) or smaller and the WW mounting method for pipe sizes 2.0 in (50.8 mm) or smaller.

The pipe curve effect on small pipe applications can cause multipath signals and measurement uncertainty. Removing extra compound along the transducer sides can eliminate the side wave paths as seen in Figure 6.5-A (below). Follow these steps to eliminate these side wave paths:

1. Apply coupling compound as usual on to the coupling surfaces, and clamp the transducers onto the pipe.

2. Use a pen-sized, standard screwdriver to remove the extra grease between the transducers and the pipe (Figure 6.5-A, below).

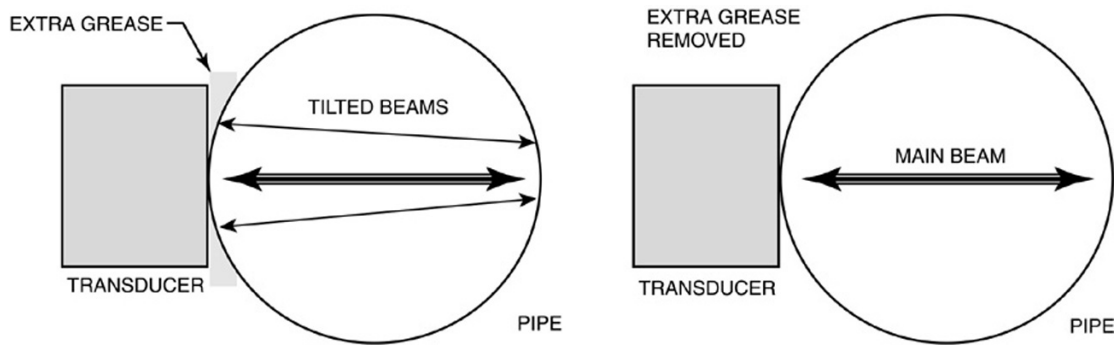


FIGURE 6.5-A

For high temperature or outdoor small pipe applications, use the foam tape strips shipped with the flowmeter to block the side wave paths. **Other tape materials generally do not satisfy performance or safety specifications.** Please contact the Thermo Customer Service Department when more tape strips are needed.

1. Wipe grease off the coupling surfaces of both transducers. Clean the surfaces with detergent and let dry. (Figure 6.5-B)

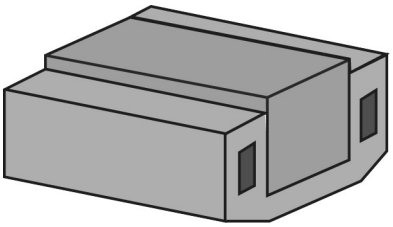


Figure 6.5-B: Applying foam tape strips, step 1

2. Draw 2 lines on each transducer surface with a pencil so that the band defined by the lines is in the middle of the surface. The spacing between the 2 lines should be as follows:

- 3.0 to 3.5 in pipes: 0.50 in (76.2 to 88.9 mm pipes: 12.7 mm);
- 2.5 to 3.0 in pipes: 0.44 in (63.5 to 76.2 mm pipes: 11.2 mm);
- 2.0 to 2.5 in pipes: 0.38 in (50.8 to 63.5 mm pipes: 9.7 mm);
- 1.5 to 2.0 in pipes: 0.32 in (38.1 to 50.8 mm pipes: 8.13 mm);
- 1.5 in and smaller pipes: 0.25 in (38.1 mm and smaller pipes: 6.35 mm). (Figure 6.5-C)

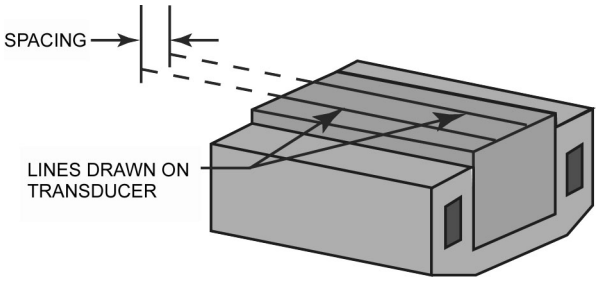


Figure 6.5-C: Applying foam tape strips, step 2

3. Remove the adhesive protection paper to expose the tape strips. Place a strip on each side of the surface along the line. Press the strips down to ensure good adhesion. (Figure 6.5-D)

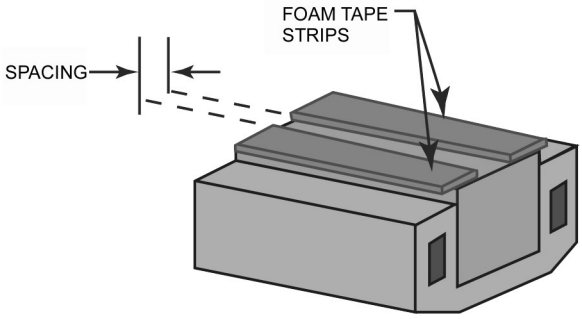


Figure 6.5-D: Applying foam tape strips, step 3

4. Apply coupling compound to the space between the tape strips. The optimum height of the compound layer is approximately one-half the height of the tape strips. (Figure 6.5-E)

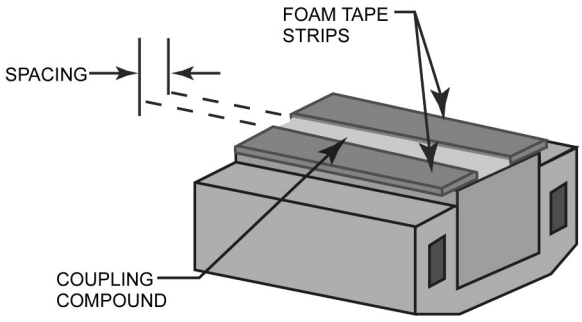


Figure 6.5-E: Applying foam tape strips, step 4

7. Emergency Overrides & Master Erase

Since these 2 procedures allow critical data to be accessed and changed, this page may be removed from the instruction manual to prevent unauthorized use of these features.

7.1 Emergency Overrides

In the event that a user-entered password is forgotten, the following emergency override passwords may be used: **42** for the system password and **43** for the scale factor password. These override passwords may not be changed or disabled.

7.2 Performing a Master Erase

This function erases all user-entered data AND data in the datalogger. Note all configuration settings and download the datalog file if a record is desired prior to performing a Master Erase.

1. Turn the flowmeter off and back on again.

2. When the message **INITIALIZING...** is displayed, press **ERASE** within 3 seconds.

3. The **Master Erase** screen is displayed (Figure 7-A). To continue with the Master Erase, press the **5** key within 3 seconds, and Figure 7-B is displayed.

4. Press the **.** (decimal) key within 3 seconds to continue.

5. If the Master Erase function is completed, Figure 7-C is displayed. If the function is not completed, Figure 7-D is displayed.

6. Enter all configuration data.

Figure 7-A

Figure 7-B

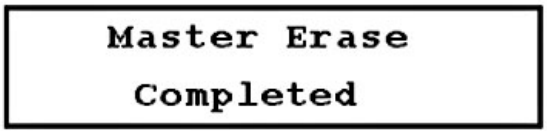


Figure 7-C

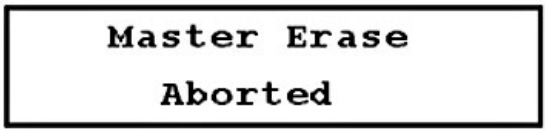


Figure 7-D

8. Flowmeter Maintenance & Troubleshooting

8.1 Replacing the Fuse

Prevent possible electrical shock and/or damage to the meter–disconnect power to the meter PRIOR to wiring.

The flowmeter has a single fuse which is mounted to the main board. The sheetmetal access cover does not need to be removed since it has a hole for accessing the fuse. To replace the fuse:

1. Disconnect power from the flowmeter.
2. Determine the cause of the fuse failure and correct if known.
3. Open the door of the flowmeter.
4. Using a small, flat-bladed screwdriver, remove the fuse and replace it with another fuse of the same rating.
5. Reconnect power to the flowmeter and verify that the unit is operating properly, e.g. the newly-installed fuse does not blow.

8.2 Replacing the Current Loop Module

Prevent possible electrical shock and/or damage to the meter–disconnect power to the meter PRIOR to wiring.

To replace the module:

1. Disconnect power from the flowmeter.
2. Open the flowmeter door, and remove the sheetmetal access cover.
3. Disconnect wiring to the module.
4. Remove the 2 screws and 4 insulating washers from the lower corners of the module. Each screw has 1 washer above and 1 washer beneath.
5. To prevent damage to the connector, grasp the module by all 4 edges and slowly lift it straight out from the main board.
6. Align the pins on the new module with the connector on the main board and press the module straight in.
7. Replace the 2 screws and 4 insulating washers.
8. Select the loop powering option according to Section 3.1 (page 9).
9. Reconnect the wiring to the module.

...8.2 Replacing the Current Loop Module continued

10. Replace the sheetmetal access cover and reconnect power to the flowmeter according to Section 2.2 (page 7).

11. Calibrate the current loop according to Section 4.13 (page 23).

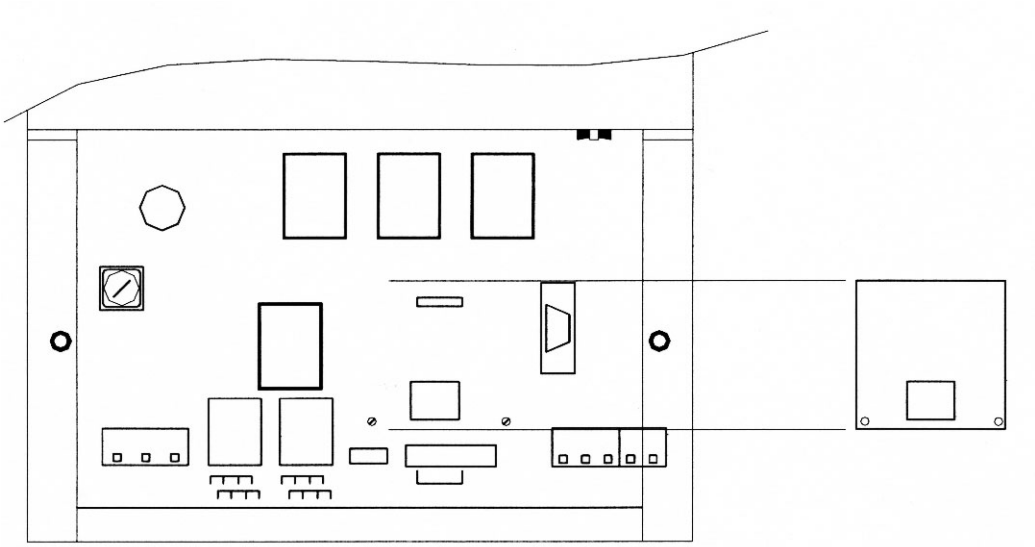


FIGURE 8.2

To ensure proper operation and to avoid damage to the module, align the pins on the module properly with the connector before inserting the module into the flowmeter. Ensure that the screw holes in the module align exactly with the mounting posts on the main board. It is possible to incorrectly align the module by 1 pin and force the holes to line up, thus damaging the module.

8.3 Replacing Sonic Coupling Compound

Any voids or air gaps that exist in the coupling compound beneath the transducers can reduce the signal and render the flowmeter inoperative. Coupling compound should be protected from washout and replaced as required. Annual replacement is recommended for most applications to maintain optimal performance.

To replace the coupling compound:

1. Remove the transducers from the pipe.

2. Clean the old compound from the transducers and the pipe.

3. Apply a wide bead of compound lengthwise down the center of each transducer face.

4. Remount the transducers, verifying that the compound is squeezing out from underneath all sides of the transducers and forming a bead along the edges.

...8.3 Replacing Sonic Coupling Compound continued

We recommend the following sonic coupling compounds:

- Sil-Glyde® (American Grease Stick Company): made from a silicon base and suited for most transducer installations; rated for pip skin temperatures from -40º to +212º F (-40º to +100º C);
- Dow Corning® 111 or similar high temperature couplant: can be used for applications with pipe skin temperatures up to 300º F (150º C);
- General Electric RTV-108 or similar silicon RTV: should be used for underground or submerged transducer sites or sites where a more permanent bond is required; RTV should be completely cured prior to covering up the transducer site or taking readings;
- Krautkramer® Hitempco (Thermo P/N 22861-0001): good high temperature couplant; should be used with optional high temperature transducers rated up to 392º F (200º C).

The transducers should not be bonded with epoxy.

8.4 Troubleshooting & Support

8.4.1 General

If the unit does not perform satisfactorily, complete the following steps until the problem is resolved:

1. Verify that the flowmeter is properly installed and that the installation site is suitable.
2. Verify that the flowmeter is properly configured.
3. Perform a Master Erase.
4. Contact the installation contractor or representative through whom the flowmeter was purchased.
5. Contact Thermo to attempt to resolve the problem over the phone.
6. If we determine the problem cannot be resolved over the phone, return the entire unit to the factory.

8.4.2 Local Representative Support

The local Thermo representative is the first contact for support and is well equipped to answer questions and provide application assistance. Your representative has access to product information and current software revisions.

8.4.3 Service & Returns

If it becomes necessary to contact the Thermo Service Center with software or hardware problems, please have the following information available:

- signal strength
- pipe orientation
- pipe ID
- fluid type
- liner thickness
- transducer type and mounting configuration
- pipe OD
- pipe material
- liner material
- model and serial numbers.

To return an instrument:

1. Contact the Thermo Service Center for an RMA number (issued by the service representative). **The receiving dock does not accept shipments without the RMA number.**

   You can contact the us at any of the following:

   - phone: (713) 272-0404
   - fax: (713) 272-5388
   - web: www.thermo.com
   - address: listed below

2. Ensure the instrument is well packed, in its original shipping box if available.

3. Include a letter fully explaining the symptoms of the failure as well as detail describing the application where the unit was being operated (type of fluid, pipe size, pipe material, fluid velocity, etc.).

4. Write the RMA number on the **outside** of the shipping box.

5. Send the unit freight-paid to:

   Thermo Electron Corporation
   Flow Systems
   9303 W. Sam Houston Parkway S.
   Houston, TX 77099
   USA

8.4.4 Upgrades

Thermo provides the most current software for your meter at time of shipment. Find out about upgrades by contacting Thermo via mail, fax, phone, or web. Upgrades are available using the RS232 port and a remote terminal.

8.5 Warranty Statement

Thermo products are warranted to be free from defects in material and workmanship at the time of shipment and for one year thereafter. Any claimed defects in Thermo products must be reported within the warranty period. Thermo shall have the right to inspect such products at Buyer's plant or to require Buyer to return such products to Thermo plant.

In the event Thermo requests return of its products, Buyer shall ship with transportation charges paid by the Buyer to Thermo plant. Shipment of repaired or replacement goods from Thermo plant shall be F.O.B. Thermo plant. A shop charge may apply for alignment and calibration services. Thermo shall be liable only to replace or repair, at its option, free of charge, products which are found by Thermo to be defective in material or workmanship, and which are reported to Thermo within the warranty period as provided above. This right to replacement shall be Buyer's exclusive remedy against Thermo.

Thermo shall not be liable for labor charges or other losses or damages of any kind or description, including but not limited to, incidental, special or consequential damages caused by defective products. This warranty shall be void if recommendations provided by Thermo or its Sales Representatives are not followed concerning methods of operation, usage and storage or exposure to corrosive conditions.

Materials and/or products furnished to Thermo by other suppliers shall carry no warranty except such suppliers' warranties as to materials and workmanship. Thermo disclaims all warranties, expressed or implied, with respect to such products.

EXCEPT AS OTHERWISE AGREED TO IN WRITING BY Thermo, THE WARRANTIES GIVEN ABOVE ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, AND Thermo HEREBY DISCLAIMS ALL OTHER WARRANTIES, INCLUDING THOSE OF MERCHANTABILITY AND FITNESS FOR PURPOSE.

9. Hazardous Area Installation

This chapter covers requirements for installing the DCT6088 in hazardous area applications. Hazardous area certification for North America is provided by the Canadian Standards Association (CSA). Certification for Europe is provided by Laboratoire Central des Industries Electrique (LCIE).

The area classification determines the type of enclosure to be used and whether barriers are required. If barriers are required, they are installed by the factory to meet the appropriate agency certification.

The standard enclosure for the DCT6088 is a NEMA 4X (IP65). The instrument is also available in an optional, factory-installed NEMA 7 explosion-proof enclosure.

If transducers are approved for use in hazardous areas, a log of the certifying agency is affixed to the transducers.

9.1 North American Certification

The transducers are certified by CSA as follows:

- intrinsically safe (IS) transducer for Classes I and II, Div. I, Groups C, D, E, F, and G (IS barriers required);
- nonincendive for the following areas (IS barriers not required):
  - Class I, Div. 2, Groups A, B, C, and D;
  - Class II, Div. 2, Groups E, F, and G.

The table below lists CSA's hazardous area installation requirements for North America.

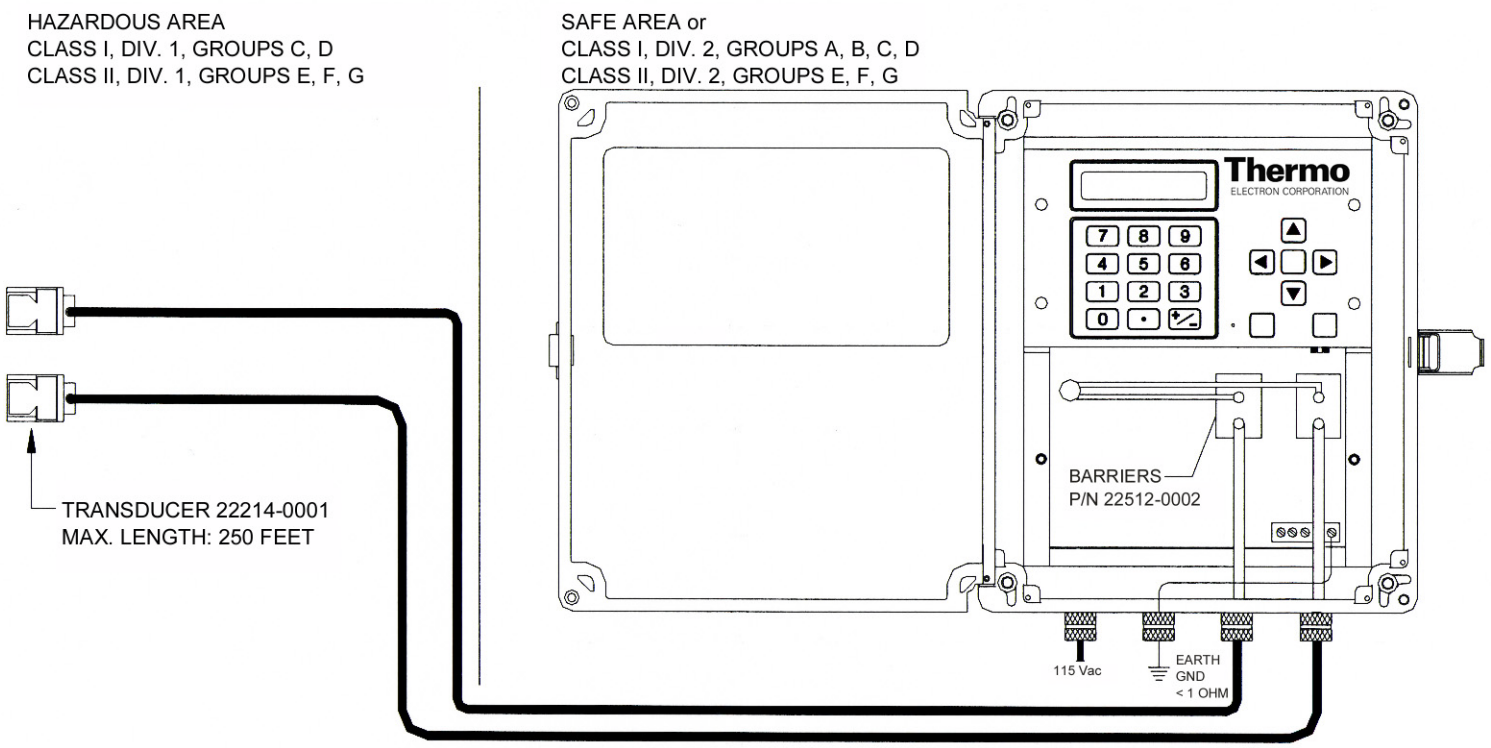
Table 4: North American Hazardous Area Installation Requirements

Item	**Division 1**	**Division 2**	**Unclassified**
Instrument	NEMA 7 enclosure[1]	NEMA 4X enclosure	NEMA 4X enclosure
Transducers	IS, barriers required	Nonincendive, barriers not required	Barriers not required
Installation drawing[2]	Figure 9.1-A	Figure 9.1-B	N/A

[1] Instrument should be installed in accordance with National Electrical Code (NEC) Article 500, including use of explosion-proof seals for the wiring connections to the enclosure.

[2] The flowmeter must be installed and wired in accordance with the specified installation drawing.

To minimize the possibility of explosion, do not disconnect equipment unless the area is known to be nonhazardous. In addition, do not replace the fuse or output module unless power has been switched off or the area is known to be nonhazardous.



NOTES:

1. Equipment connected to the 4-20 mA port, the RS232 port, or the optional relay board must be powered from 120 Vac or less for applications requiring hazardous area location of transmitter.
2. Installation should be in accordance with the CEC or NEC.
3. Resistance between IS ground and earth ground must be less than 1 ohm.
4. Control equipment connected to barrier must not use or generate more than 250 V.
5. IS wiring must be separated from other wiring.
6. Flowmeter can be any peek measurement flowmeter which outputs less than 140 V.

FIGURE 9.1-A: NORTH AMERICAN IS (DIV. 1) HAZARDOUS AREA INSTALLATION (REFER TO DRAWING 22493-0003)

NOTES:

1. Equipment connected to the 4-20 mA port, the RS232 ports, or the optional relay board must be powered from 120 VAC or less for applications requiring hazardous area location of transmitter.
2. Installation should be in accordance with the CEC or NEC.
3. Nonincendive wiring must be separated from other wiring.

FIGURE 9.1-B: NORTH AMERICAN NONINCENDIVE (DIV. 2) HAZARDOUS AREA INSTALLATION (REFER TO DRAWING 22493-0001)

9.2 European Certification

The transducers are certified IS by LCIE for EEx ia IIB T6 when IS barriers are installed. The table below lists the European hazardous area installation requirements.

Table 5: European Hazardous Area Installation Requirements

Item	**Zone 0**	**Zone 1**	**Zone 2**	**Unclassified**
Instrument	N/A	EExd[1] enclosure	EExd[1] enclosure	IP65 enclosure
Transducers	EEx ia, barriers required	EEX ia, barriers required	EEX ia, barriers required	Barriers not required
Installation drawing[2]	Figure 9.2	Figure 9.2	Figure 9.2	N/A

[1] Instrument should be installed in accordance with required codes, including use of explosion-proof seals for the wiring connections to the enclosure.

[2] The flowmeter must be installed and wired in accordance with the specified installation drawing.

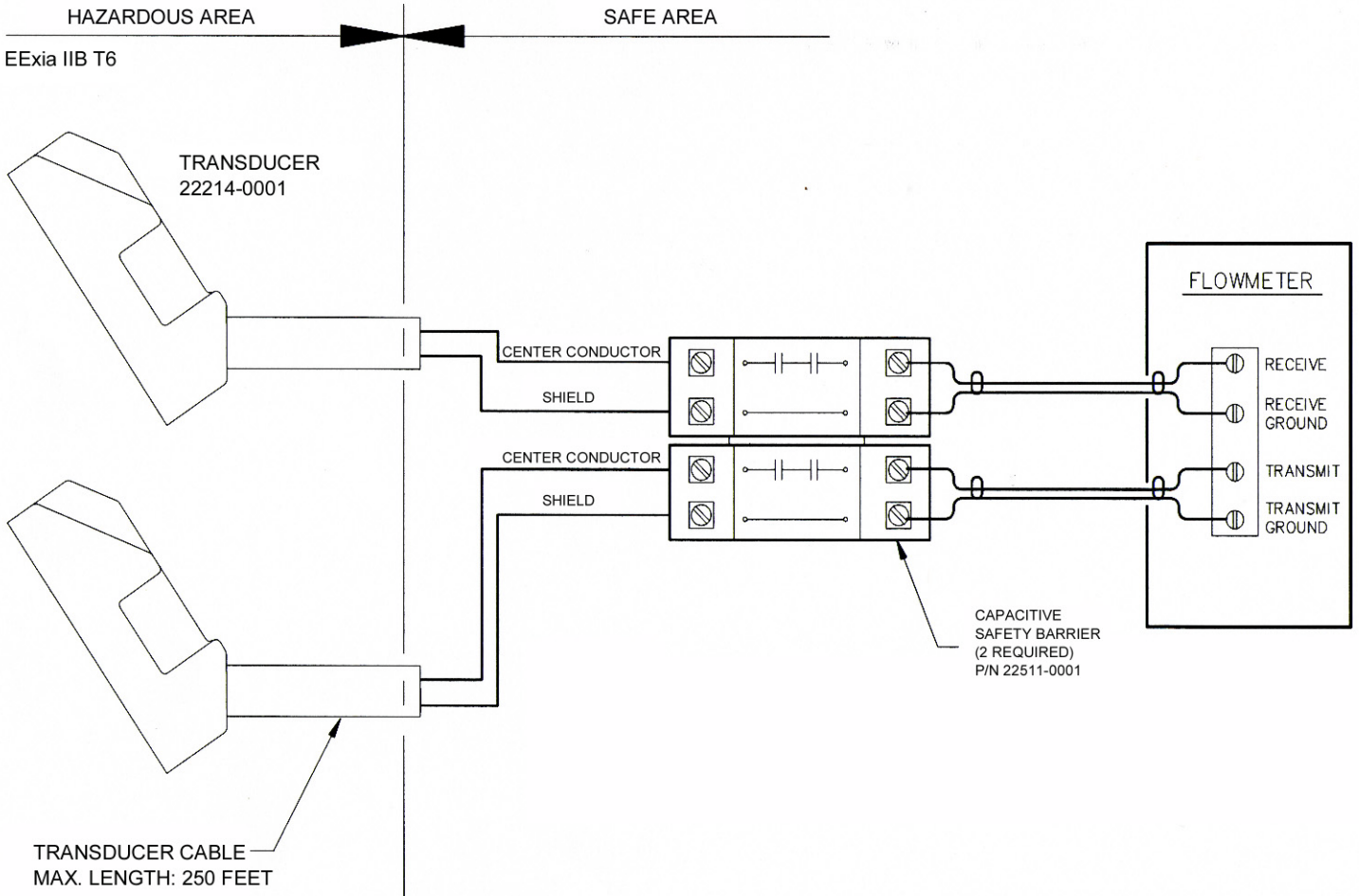


FIGURE 9.2: EUROPEAN HAZARDOUS AREA INSTALLATION (REFER TO DRAWING 22493-0005)

NOTES:

1. Barrier must be installed in an enclosure that meets the requirements of ANSI/ISA S82.
2. Control equipment connected to barrier must not use or generate more than 120 V.
3. Installation should be in accordance with CENELEC.
4. CENELEC control drawing. No changes without prior CENELEC approval.
5. Equipment connected to the 4-20 mA port or RS232 port or the optional relay board must be powered from 120 Vac or less for applications requiring hazardous area location of transmitter.

9.3 North American Hazardous Area Installation Definitions

This section provides hazardous area installation definitions for North America to assist in determining the operating environment for the DCT6088. Refer to the National Electrical Code (NEC) Article 500 for more information on hazardous area definitions for North America.

Class I: highly flammable gases or vapors
Class II: combustible dust
Class III: combustible fibers or flyings
Division 1: intermittent or continuous hazard
Division 2: hazard under abnormal conditions
Group A: atmospheres containing acetylene
Group B: atmospheres containing hydrogen or gases of equivalent hazard
Group C: atmospheres containing ethyl-ether vapors, ethylene or cyclopropane
Group D: atmospheres containing gasoline, hexane, benzene, butane, propane, alcohols, acetone, benzol, lacquer solvent vapors, or natural gas
Group E: atmospheres containing metal dust
Group F: atmospheres containing coal dust
Group G: atmospheres containing grain dust
NEMA 4X: watertight enclosures; must pass hose test using 1-inch nozzle delivering 65 GPM at a 10-ft distance for 5 minutes; additional corrosion-resistant characteristics, having no exposed metal surfaces
NEMA 7: explosion-proof enclosures for indoor hazardous locations (Class I, Groups A, B, C, and D)

9.4 European Hazardous Area Installation Definitions

This section provides hazardous area installation definitions for Europe to assist in determining the operating environment for the DCT6088. Refer to International Electrotechnical Commission (EIC) 79 for more information on hazardous area definitions for Europe.

EEx ia IIB T6: IS classification; surface industry equipment used in flammable atmospheres equivalent to ethylene or less; maximum surface temperature of 185º F (85º C)
IP65: dust-tight enclosure; protection against low pressure jets of water from all directions (limited ingress permitted)

9.5 CE Certification Requirements

The table below provides supplemental information for European units requiring CE certification.

Table 6: CE Certification Requirements	
Insulation rating	double
Environmental operating conditions (per EN-61010-1)	• Pollution degree: 1 • Installation category (over-voltage): II
Peripheral connections	equipment should only be connected to peripherals conforming to installation category II
External isolator	switch or circuit breaker must be located near the equipment if the equipment is to be permanently connected
Fuses (per EN-61010-1, Sections 5.1.4 and 5.4.5)	• user-replaceable fuse for AC-powered versions: 500 mA, 250 V, quick acting, 5 x 20 mm • user-replaceable fuse for DC-powered versions: 1 A, 250 V, quick acting, 5 x 20 mm • non user-replaceable fuse for all versions: 5 A, 250 V, quick acting
Output isolation	5 kVac surge isolation when powered from an external source; not to be connected to continuous voltages in excess of 50 Vac with respect to ground (earth)

APPENDIX A: PIPE SCHEDULES

This appendix provides pipe schedules as a convenient reference for the following pipe materials: steel, stainless steel, and PVC (Table A-1); cast iron (Table A-2); ductile iron (Table A-3).

The inside diameters (IDs) listed in the following tables are calculated from the outside diameter (OD) and minimum wall thicknesses as specified in applicable standards. The actual pipe ID may vary from the dimension listed in the tables by as much as 25% of the pipe minimum wall thickness. The accuracy of flow rate measurement is enhanced if the pipe ID is actually measured.

Table A-1
Steel, Stainless Steel and PVC Pipe Standard Schedules
Inside Diameter (ID) and Outside Diameter (OD) in Inches

Nominal Pipe Size ( )	Outside Diameter (OD)	Sched. 5	Sched. 10 (Light Wall)	Sched. 20	Sched. 30	Sched. 40	Sched. 60	Sched. 80	Sched. 100	Sched. 120	Sched. 140	Sched. 160	Std. Wall	X STG
1	1.315	1.185	1.097			1.049		0.957				0.815	1.049	0.957
1.25	1.660	1.530	1.442			1.380		1.278				1.160	1.380	1.278
1.5	1.900	1.770	1.682			1.610		1.500				1.338	1.610	1.500
2	2.375	2.245	2.157			2.067		1.939				1.687	2.067	1.939
2.5	2.875	2.709	2.635			2.469		2.323				2.125	2.469	2.323
3	3.500	3.334	3.260			3.068		2.900				2.624	3.068	2.900
3.5	4.000	3.834	3.760			3.548		3.364					3.548	3.364
4	4.500	4.334	4.260			4.026		3.826		3.624		3.438	4.026	3.826
5	5.563	5.345	5.295			5.047		4.813		4.563		4.313	5.047	4.813
6	6.625	6.407	6.357			6.065		5.761		5.501		5.187	6.065	5.761
8	8.625	8.407	8.329	8.125	8.071	7.981	7.813	7.625	7.437	7.187	7.001	6.813	7.981	7.625
10	10.750	10.482	10.420	10.250	10.136	10.020	9.750	9.562	9.312	9.062	8.750	8.500	10.020	9.750
12	12.750	12.438	12.390	12.250	12.090	11.938	11.626	11.374	11.062	10.750	10.500	10.126	12.000	11.750
14	14.000		13.500	13.376	13.250	13.124	12.812	12.500	12.124	11.876	11.500	11.188	13.250	13.000
16	16.000	15.670	15.500	15.376	15.250	15.000	14.688	14.312	13.938	13.562	13.124	12.812	15.250	15.000
18	18.000	17.670	17.500	17.376	17.124	16.876	16.500	16.124	15.688	15.255	14.876	14.438	17.250	17.000
20	20.000	19.634	19.500	19.250	19.000	18.812	18.376	17.938	17.438	17.000	16.500	16.062	19.250	19.000
24	24.000	23.564	23.500	23.250	22.876	22.624	22.062	21.562	20.938	20.376	19.876	19.312	23.250	23.000
30	30.000	29.500	29.376	29.000	28.750	28.500							29.250	29.000
36	36.000		35.376	35.000	34.750	34.500					31.876	31.312	35.250	35.000
42	42.000			41.000	40.750	40.500							41.250	41.000
48	48.000					47.250							47.250	47.000

Table A-2
Cast Iron Pipe Standard Classes
Inside Diameter (ID) and Outside Diameter (OD) in Inches

Nominal Pipe Size ( )	Class A		Class B		Class C		Class D		Class E		Class F		Class G		Class H	
	OD	ID	OD	ID	OD	ID	OD	ID	OD	ID	OD	ID	OD	ID	OD	ID
3	3.80	3.02	3.96	3.12	3.96	3.06	3.96	3.00								
4	4.80	3.96	5.00	4.10	5.00	4.04	5.00	3.96								
6	6.90	6.02	7.10	6.14	7.10	6.08	7.10	6.00	7.22	6.06	7.22	6.00	7.38	6.08	7.38	6.00
8	9.05	8.13	9.05	8.03	9.30	8.18	9.30	8.10	9.42	8.10	9.42	8.10	9.60	8.10	9.60	8.00
10	11.10	10.10	11.10	9.96	11.40	10.16	11.40	10.04	11.60	10.12	11.60	10.00	11.84	10.12	11.84	10.00
12	13.20	12.12	13.20	11.96	13.50	12.14	13.50	12.00	13.78	12.14	13.78	12.00	14.08	12.14	14.08	12.00
14	15.30	14.16	15.30	13.98	15.65	14.17	15.65	14.01	15.98	14.18	15.98	14.00	16.32	14.18	16.32	14.00
16	17.40	16.20	17.40	16.00	17.80	16.20	17.80	16.02	18.16	16.20	18.16	16.00	18.54	16.18	18.54	16.00
18	19.50	18.22	19.50	18.00	19.92	18.18	19.92	18.00	20.34	18.20	20.34	18.00	20.78	18.22	20.78	18.00
20	21.60	20.26	21.60	20.00	22.06	20.22	22.06	20.00	22.54	20.24	22.54	20.00	23.02	20.24	23.02	20.00
24	25.80	24.28	25.80	24.02	26.32	24.22	26.32	24.00	26.90	24.28	26.90	24.00	27.76	24.26	27.76	24.00
30	31.74	28.98	32.00	29.94	32.40	30.00	32.74	30.00	33.10	30.00	33.46	30.00				
36	37.96	35.98	38.30	36.00	38.70	35.98	39.16	36.00	39.60	36.00	40.04	36.00				
42	44.20	42.00	44.50	41.94	45.10	42.02	45.58	42.02								
48	50.50	47.98	50.80	47.96	51.40	47.98	51.98	48.00								
54	56.66	53.96	57.10	54.00	57.80	54.00	58.40	53.94								
60	62.80	60.02	63.40	60.06	64.20	60.20	64.82	60.06								
72	75.34	72.10	76.00	72.10	76.88	72.10										
84	87.54	84.10	88.54	84.10												

NOTE: For pipes with cement linings, reduce the pipe inside diameter by two times the lining thickness. Standard and double cement lining thicknesses are listed in Table A-3.

Table A-3
Ductile Iron Pipe Standard Classes
Inside Diameter (ID) and Outside Diameter (OD) in Inches

Nominal Pipe Size	Outside Diameter (OD)	Inside Diameter							Cement Lining (See Note)	
		Class 50	Class 51	Class 52	Class 53	Class 54	Class 55	Class 56	Standard Thickness	Double Thickness
3	3.96		3.46	3.40	3.34	3.28	3.22	3.16	0.125	0.250
4	4.80		4.28	4.22	4.16	4.10	4.04	3.98		
6	6.90	6.40	6.34	6.28	6.22	6.16	6.10	6.04		
8	9.05	8.51	8.45	8.39	8.33	8.27	8.21	8.15		
10	11.10	10.52	10.46	10.40	10.34	10.28	10.22	10.16		
12	13.20	12.58	12.52	12.46	12.40	12.34	12.28	12.22		
14	15.30	14.64	14.58	14.52	14.46	14.40	14.34	14.28	0.1875	0.375
16	17.40	16.72	16.66	16.60	16.54	16.48	16.42	16.36		
18	19.50	18.80	18.74	18.68	18.62	18.56	18.50	18.44		
20	21.60	20.88	20.82	20.76	20.70	20.64	20.58	20.52		
24	25.80	25.04	24.98	24.92	24.86	24.80	24.74	24.68		
30	32.00	31.22	31.14	31.06	30.98	30.90	30.82	30.74	0.250	0.500
36	38.30	37.44	37.34	37.06	37.14	37.04	36.94	36.84		
42	44.50	43.56	43.44	43.32	43.20	43.08	42.96	42.84		
48	50.80	49.78	49.64	49.50	49.36	49.22	49.08	48.94		
54	57.10	55.96	55.80	55.64	55.48	55.32	55.16	55.00		

Note: For pipes with cement linings, reduce the pipe inside diameter by two times the lining thickness listed above.

APPENDIX B: FLUID PROPERTIES

B.1 Fluid Sound Velocities & Kinematic Viscosities

This section provides a table of fluid sound speeds and kinematic viscosities. The information is based on material from the *Cameron Hydraulic Data Book* (17th ed., Ingersoll-Rand, 1988) and *Table of Physical and Chemical Constants* (13th ed., Longmans, 1966).

Note that viscosity does not have as significant an effect on flow accuracy as sound speed since viscosity is only used to calculate flow profile. Even a comparatively large error in viscosity results in a change of only 2 to 5 percent.

LIQUID	t°C	c(m/s)	t° F	c(ft/s)	cSt
Acetaldehyde CH_3CHO	16.1 20	--- ---	61 68	--- ---	0.305 0.295
Acetic acid	50	1584	122	5196	---
10%.....	15	---	59	---	1.35
50%.....	15	---	59	---	2.27
80%.....	15	---	59	---	2.85
Conc.-glacial.....	15	---	59	---	1.34
Acetic anhydride	24 15	1384 ---	75 59	4540 ---	--- 0.88
Acetone CH_3COCH_3	20	1190	68	3903	0.41
Acetylene tetrabromide	28	1007	82	3303	---
Acetylene tetrachloride	28	1155	82	3788	---
Alcohol allyl.....	 20 40	 --- ---	 68 104	 --- ---	 1.60 0.90
butyl-n.....	20 70	--- ---	68 158	--- ---	3.64 1.17
ethyl (grain) C_2H_5OH.....	20 37.8	--- ---	68 100	--- ---	1.52 1.2
methyl (wood) CH_3OH	15 0	--- ---	59 32	--- ---	0.74 1.04
propyl.....	20 50	--- ---	68 122	--- ---	2.8 1.4
Ammonia	-17.8	---	0	---	0.30

LIQUID	T°C	c(m/s)	t°F	c(ft/s)	cSt
Amyl acetate	29.2	1173	85	3847	---
n-Amyl alcohol	28.6	1224	83	4015	---
iso-Amyl ether	26	1153	79	3782	---
Aniline	20 10	1656 ---	68 50	5432 ---	4.37 6.4
Argon	-183.0	816.7	-297	2679	---
Asphalt, blended					
RC-0, MC-0, SC-0	25 37.8	--- ---	77 100	--- ---	159 - 324 60 - 108
RC-1, MC-1, SC-1	37.8 50	--- ---	100 122	--- ---	518 - 1080 159 - 324
RC-2, MC-2, SC-2	50 60	--- ---	122 140	--- ---	518 - 1080 215 - 430
RC-3, MC-3, SC-3	50 60	--- ---	122 140	--- ---	1295 - 2805 540 - 1080
RC-4, MC-4, SC-4	60 82.8	--- ---	140 180	--- ---	1725 - 4315 270 - 540
RC-5, MC-5, SC-5	60 82.8	--- ---	140 180	--- ---	6040 - 18340 647 - 1295
RS-1, MS-1, SS-1	25 37.8	--- ---	77 100	--- ---	33 - 216 19 - 75
Asphalt emulsions					
Fed #1.....	25 37.8	--- ---	77 100	--- ---	215 - 1510 75 - 367
Fed #2, V, VI.....	25 37.8	--- ---	77 100	--- ---	33 - 216 19 - 75

LIQUID	t° C	c(m/s)	t° F	c(ft/s)	cSt
Automotive crankcase oils					
SAE-5W	-17.8	---	0	---	1295 max
SAE-10W	-17.8	---	0	---	1295 - 2590
SAE-20W	-17.8	---	0	---	2590 - 10350
SAE-20	98.9	---	210	---	5.7 - 9.6
SAE-30	98.9	---	210	---	9.6 - 12.9
SAE-40	98.9	---	210	---	12.9 - 16.8
SAE-50	98.9	---	210	---	16.8 - 22.7
Automotive gear oils					
SAE-75W	98.9	---	210	---	4.2 min
SAE-80W	98.9	---	210	---	7.0 min
SAE-85W	98.9	---	210	---	11.0 min
SAE-90	98.9	---	210	---	14 - 25
SAE-14Q	98.9	---	210	---	25 - 43
SAE 150	98.9	---	210	---	43 min
Beer	20	---	68	---	1.8
Benzene (Benzol) C_6H_6	20 0	1321 ---	68 32	4333 ---	0.744 1.00
Benzophenone	100	1316	212	4316	---
Bismuth	285	1663	545	5455	---
Bone Oil	54.4 100	--- ---	130 212	--- ---	47.5 11.6
Bromine	20	---	68	---	0.34
Bromobenzene	50	1074	122	3523	---
Bromoform	25	908	77	2978	---
Butane-n	-1.1 ---	--- ---	-50 30	--- ---	0.52 0.35
Butyl acetate	30	1172	86	3844	---
n-Butyl alcohol	20	1257.7	68	4125	---
iso-Butyl bromide	-104	1450	-155	4756	---
Butyric acid n	20 0	--- ---	68 32	--- ---	1.61 2.3cp
Cadmium	360	2150	680	7052	---

LIQUID	t° C	c(m/s)	t° F	c(ft/s)	cSt
Caesium	130	967	266	3172	---
Calcium chloride					
5%	18.3	---	65	---	1.156
25%	15.6	---	60	---	4.0
Carbolic acid (phenol)	18.3	---	65	---	11.83
Carbon tetrachloride CCl_4	20	---	68	---	0.612
	37.8	---	100	---	0.53
Carbon disulphide CS_2	25	1149	77	3769	---
	0	---	32	---	0.33
	20	---	68	---	0.298
Carbon tetrachloride	20	938	68	3077	---
Castor oil	18.6	1500	65	4920	---
	37.8	---	100	---	259-325
	54.4	---	130	---	98-130
China wood oil	20.6	---	69	---	308.5
	37.8	---	100	---	125.5
Chlorine	20	850	68	2788	---
m-Chlornitrobenzene	40	1368	104	4487	---
Chlorobenzene	25	1302	77	4271	---
Chloroform	20	---	68	---	0.38
	25	995	77	3264	---
	60	---	140	---	0.35
Cocoanut oil	37.8	---	100	---	29.8 - 31.6
	54.4	---	130	---	14.7 - 15.7
Cod oil	37.8	---	100	---	32.1
	54.4	---	130	---	19.4
Corn oil	54.4	---	130	---	28.7
	100	---	212	---	8.6
Corn starch solutions					
22 Baume	21.1	---	70	---	32.1
	37.8	---	100	---	27.5
24 Baume	21.1	---	70	---	129.8
	37.8	---	100	---	95.2
25 Baume	21.1	---	70	---	303
	37.8	---	100	---	173.2

LIQUID	t° C	c(m/s)	t° F	c(ft/s)	cSt
Cotton seed oil	37.8 54.4	--- ---	100 130	--- ---	37.9 20.6
Crude Oil 48°API	15.6 54.4	--- ---	60 130	--- ---	3.8 1.6
40°API	15.6 54.4	--- ---	60 130	--- ---	9.7 3.5
35.6 API	15.6 54.4	--- ---	60 130	--- ---	17.8 4.9
32.6 API	15.6 54.4	--- ---	60 130	--- ---	23.2 7.1
Salt Creek	15.6 54.4	--- ---	60 130	--- ---	77 6.1
Cyclohexane	20	1278	68	4192	---
Cyclohexanol	30	1622	86	5320	---
Decane-n	-17.8 37.8	--- ---	0 100	--- ---	2.36 1.001
l-Decene	20	1250	68	4100	---
Deuterium oxide	20	1381	68	4530	---
Diesel fuel oils 2D	37.8 54.4	--- ---	100 130	--- ---	2 - 6 1 - 3.97
3D	37.8 54.4	--- ---	100 130	--- ---	6 - 11.75 3.97 - 6.78
4D	37.8 54.4	--- ---	100 130	--- ---	29.8 max 13.1 max
5D	50 71.1	--- ---	122 160	--- ---	86.6 max 35.2 max
Diethyl Ether	20	---	68	---	0.32
Diethylene glycol	21.1 30	--- 1533	70 86	--- 5028	32 ---
Diethylene glycol monoethyl ether	30	1296	86	4251	---
Dimethyl siloxane (Dow Corning® 200 fluid)	20	912.3	68	2992	---

LIQUID	t° C	c(m/s)	t° F	c(ft/s)	cSt
Diphenyl	100	1271	212	4169	---
Diphenyl ether	30	1462	86	4795	---
Ethanol	20	1156	68	3792	---
Ethanol amide	25	1724	77	5655	---
Ether (diethyl)	25	985	77	3231	---
Ethyl acetate $CH_3COOC_2H_5$	15 20	--- 1133	59 68	--- 3716	0.4 0.49
Ethyl alcohol	20	1161.8	68	3811	---
Ethyl bromide C_2H_5Br	10 20	932 ---	50 68	3057 ---	--- 0.27
Ethyl glycol	30	1606	86	5268	---
Ethyl iodide	20	876	68	2873	---
Ethylene bromide	20	---	68	---	0.787
Ethylene chloride	20	---	68	---	0.668
Ethylene dibromide	24	1014	75	3326	---
Ethylene dichloride	23	1240	73	4067	---
Ethylene glycol	21.1 30	--- 1616	70 86	--- 5300	17.8 ---
Ethylene glycol monoethyl ether	30	1279	86	4195	---
Ethylene glycol monomethyl ether	30	1339	86	4392	---
Formaldehyde	25	1587	77	5205	---
Formamide	25	1610	77	5281	---
Formic acid 10%	20 20	1299 ---	68 68	4261 ---	--- 1.04
50%	20	---	68	---	1.2
80%	20	---	68	---	1.4
Conc.	20	---	68	---	1.48

LIQUID	t° C	c(m/s)	t° F	c(ft/s)	cSt
Freon					
-11	21.1	---	70	---	0.21
-12	21.1	---	70	---	0.27
-21	21.1	---	70	---	1.45
Fuel Oils					
1	21.1	---	70	---	2.39 - 4.28
	37.8	---	100	---	2.69
2	21.1	---	70	---	3.0 - 7.4
	37.8	---	100	---	2.11 - 4.28
3	21.1	---	70	---	2.69 - 5.84
	37.8	---	100	---	2.06 - 3.97
5A	21.1	---	70	---	7.4 - 26.4
	37.8	---	100	---	4.91 - 13.7
5B	21.1	---	70	---	26.4-
	37.8	---	100	---	13.6 - 67.1
6	50	---	122	---	97.4 - 660
	71.1	---	160	---	37.5 - 172
Gallium	50	2740	122	8987	---
Gas oils	21.1	---	70	---	13.9
	37.8	---	100	---	7.4
Gasolines					
a	15.6	---	60	---	0.88
	37.8	---	100	---	0.71
b	15.6	---	60	---	0.64
c	15.6	---	60	---	0.46
	37.8	---	100	---	0.40
Glycerine	30	1923	86	6307	---
100%	20.3	---	69	---	648
	37.8	---	100	---	176
50% Water	20	---	68	---	5.29
	60	---	140	---	1.85cp
Glucose	37.8	---	100	---	7.7M - 22M
	65.6	---	150	---	880 - 2420
Guaicol	100	1252	212	4107	---
Helium	-268.8	179.8	-452	590	---

LIQUID	t° C	c(m/s)	t° F	c(ft/s)	cSt
n-Heptane	-17.8	---	0	---	0.928
	22.4	1150	72	3772	---
	37.8	---	100	---	0.511
Heptene	30	1082	86	3549	---
Heptyne	30	1159	86	3802	---
Hexane	20	1203	68	3946	---
n-Hexane	-17.8	---	0	---	0.683
	21.2	1085	70	3559	---
	37.8	---	100	---	0.401
Honey	37.8	---	100	---	73.6
Hydrogen	-256	1187	-429	3893	---
Industrial lubricants					
Turbine oils					
685	15.6	---	60	---	647
SSU at 100°F	93.3	---	200	---	14.5
420	15.6	---	60	---	367
SSU	93.3	---	200	---	11
315	15.6	---	60	---	259
SSU	93.3	---	200	---	8
215	15.6	---	60	---	151
SSU	93.3	---	200	---	7.3
150	15.6	---	60	---	99
SSU	93.3	---	200	---	6
Machine lubricants					
#8	37.8	---	100	---	23 - 34
	54.4	---	130	---	13 - 18
#10	37.8	---	100	---	34 - 72
	54.4	---	130	---	18 - 25
#20	37.8	---	100	---	72 - 83
	54.4	---	130	---	25 - 39
#30	37.8	---	100	---	75 - 119
	54.4	---	130	---	39 - 55

LIQUID	t° C	c(m/s)	t° C	c(ft/s)	cSt
Machine lubricants, cont					
Cutting oils					
#1.....	37.8	---	100	---	30 - 40
	54.4	---	130	---	17 - 23
#2.....	37.8	---	100	---	40 - 46
	54.4	---	130	---	23 - 26
Indium	260	2215	500	7265	---
Ink, printers	37.8	---	100	---	550 - 2200
	54.4	---	130	---	238 - 660
Insulating oil	21.1	---	70	---	24.1 max
	37.8	---	100	---	11.75 max
Kerosene	20	---	68	---	2.71
	25	1315	77	4313	---
Jet Fuel (av)	-34.4	---	-30	---	7.9
Lard	37.8	---	100	---	62.1
	54.4	---	130	---	34.3
Lard oil	37.8	---	100	---	41 - 47.5
	54.4	---	130	---	23.4 - 27.1
Lead	340	1760	644	5773	----
Linseed oil	37.8	---	100	---	30.5
	54.4	---	130	---	18.94
Menhadden oil	37.8	---	100	---	29.8
	54.4	---	130	---	18.2
Menthol	50	1271	122	4169	---
Merck	20.2	1482.3	68	4862	---
Mercury	20	1454	68	4769	---
	21.1	---	70	---	0.118
	37.8	---	100	---	0.11
Methanol	20	1118	68	3667	---
Methyl acetate	20	---	68	---	0.44
	30	1131	86	3710	---
Methyl alcohol	20	1121.2	68	3678	---
Methyl bromide	2	905	36	2968	---

LIQUID	t° C	c(m/s)	t° F	c(ft/s)	cSt
Methylene chloride	23.5	1064	74	3490	---
Methylene iodide	24	977.7	75	3207	---
Milk	20	---	68	---	1.13
Molasses					
A, first.....	37.8	---	100	---	281 - 5070
	54.4	---	130	---	151 - 1760
B, second.....	37.8	---	100	---	1410 - 13.2M
	54.4	---	130	---	660 - 3.3M
C, blackstrap.....	37.8	---	100	---	2630 - 55M
	54.4	---	130	---	1320 - 16.5M
Naphthalene	80	---	176	---	0.9
Naptha	25	1225	77	4018	---
Neatsfoot oil	37.8	---	100	---	49.7
	54.4	---	130	---	27.5
Nitrobenzene	20	---	68	---	1.67
	23.8	1462	75	4795	---
Nitrogen	-188.9	744.7	-308	2443	---
Nonane	20	1248	68	4093	---
l-Nonene	20	1218	68	3995	---
Nonene-n	-17.8	---	0	---	1.728
	37.8	---	100	---	0.807
n-Octane	-17.8	---	0	---	1.266
	20	1192	68	3910	---
	37.8	---	100	---	0.645
Oil (lubricating)	10	1625	50	5330	---
Oil of camphor	25	1390	77	4559	---
Oleic acid	20	1442	68	4730	---
Olive oil	21.7	1440	71	4723	---
	37.8	---	100	---	43.2
	54.4	---	130	---	24.1
Oxygen	-182.9	912	-297	2991	---
Palm oil	37.8	---	100	---	47.8
	54.4	---	130	---	26.4

LIQUID	$t^{o}C$	c(m/s)	$t^{o}F$	c(ft/s)	cSt
Paraldehyde	28	1197	82	3926	---
Peanut oil	37.8 54.4	--- ---	100 130	--- ---	42 23.4
l-Pentadecene	20	1351	68	4431	---
Pentane	20	1008	68	3306	---
iso-Pentane	25	985	77	3231	---
n-Pentane	-17.8 20 26.7	--- 1044 ---	0 68 80	--- 3424 ---	0.508 --- 0.342
Petrolatum	54.4 71.1	--- ---	130 160	--- ---	20.5 15
Petroleum ether	15.6	---	60	---	31(est)
Phenol	100	1274	212	4179	---
Potassium	150	1840	302	6035	---
n-Propanol	20	1220	68	4002	---
Propionic acid	20	---	68	---	1.13
n-Propyl acetate	26	1182	79	3877	---
n-Propyl alcohol	20	1223.2	68	4012	---
Propylene glycol	21.1	---	70	---	52
Pyridine	20	1445	68	4740	---
Quenching oil (typical)	---	---	---	---	100 - 120
Rapeseed oil	37.8 54.4	--- ---	100 130	--- ---	54.1 31
Rosin oil	37.8 54.4	--- ---	100 130	--- ---	324.7 129.9
Rosin (wood)	37.8 93.3	--- ---	100 200	--- ---	216 - 11M 108 - 4400
Rubidium	160	1260	320	4133	---
Sesame seed oil	37.8 54.4	--- ---	100 130	--- ---	39.6 23
Silicon tetrachloride	30	766.2	86	2513	---

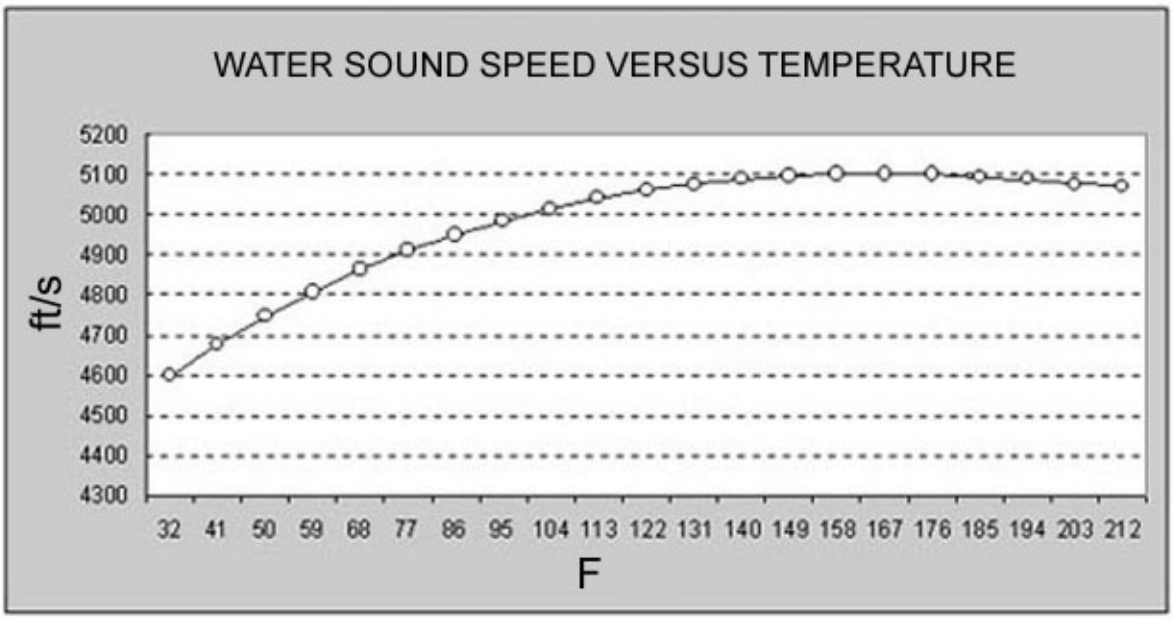
LIQUID	t° C	c(m/s)	t° F	c(ft/s)	cSt
Sodium	150	2500	302	8200	---
Sodium chloride (fused)	850	1991	1562	6530	---
5%.....	20	---	68	---	1.097
25%.....	15.6	---	60	---	2.4
Sodium hydroxide (caustic soda) 20%.....	18.3	---	65	---	4.0
30%.....	18.3	---	65	---	10.0
Soya bean oil	37.8 54.4	--- ---	100 130	--- ---	35.4 19.64
Sperm oil	37.8 54.4	--- ---	100 130	--- ---	21 - 23 15.2
Sugar solutions Corn syrup 86.4 Brix	37.8 82.2	--- ---	100 180	--- ---	180Mcp 1750cp
84.4 Brix	37.8 82.2	--- ---	100 180	--- ---	48Mcp 800cp
82.3 Brix	37.8 82.2	--- ---	100 180	--- ---	17Mcp 380cp
80.3 Brix	37.8 82.2	--- ---	100 180	--- ---	6900cp 230cp
78.4 Brix	37.8 82.2	--- ---	100 180	--- ---	3200cp 160cp
Sugar solutions Sucrose 60 Brix	21.1 37.8	--- ---	70 100	--- ---	49.7 18.7
64 Brix	21.1 37.8	--- ---	70 100	--- ---	95.2 31.6
68 Brix	21.1 37.8	--- ---	70 100	--- ---	216.4 59.5
72 Brix	21.1 37.8	--- ---	70 100	--- ---	595 138.6
74 Brix	21.1 37.8	--- ---	70 100	--- ---	1210 238

LIQUID	t° C	c(m/s)	t° F	c(ft/s)	cSt
Sugar solutions, cont Sucrose 76 Brix	 21.1 37.8	 --- ---	 70 100	 --- ---	 2200 440
Sulphur	130	1332	266	4369	---
Sulphuric acid 100%	20	---	68	---	14.6
95%	20	---	68	---	14.5
60%	20	---	68	---	4.4
Tar, coke oven	21.1 37.8	--- ---	70 100	--- ---	600 - 1760 141 - 308
Tar, gas house	21.1 37.8	--- ---	70 100	--- ---	3300 - 66M 440 - 4400
Tar, pine	37.8 55.6	--- ---	100 132	--- ---	559 108.2
Tar, road - RT-2.....	 50 100	 --- ---	 122 212	 --- ---	 43.2 - 64.9 8.88 - 10.2
RT-4.....	50 100	--- ---	122 212	--- ---	86.6 - 154 11.6 - 14.3
RT-6.....	50 100	--- ---	122 212	--- ---	216 - 440 16.8 - 26.2
RT-8.....	50 100	--- ---	122 212	--- ---	660 - 1760 31.8 - 48.3
RT-10.....	50 100	--- ---	122 212	--- ---	4.4M - 13.2M 53.7 - 86.6
RT-12.....	50 100	--- ---	122 212	--- ---	25M - 75M 108 - 173
Tetralin	20	1484	68	4868	---
Tin (molten)	240	2470	464	8102	---
Toluene	20 30	--- 1275	68 86	--- 4182	0.68 ---
o-Toluidine	22.5	1669	73	5474	---
l-Tridecene	20	1313	68	4307	---

LIQUID	t° C	c(m/s)	t° F	c(ft/s)	cSt
Trielhylene glycol	21.1	---	70	---	40
Triethylamine	0	1189	32	3900	---
Turpentine	25 37.8 54.4	1225 --- ---	77 100 130	4018 --- ---	--- 86.6 - 95.2 39.9 - 44.3
l-Undecene	20	1275	68	4182	---
Varnish, spar	20 37.8	--- ---	68 100	--- ---	313 143
Water distilled.....	20	1482.9	68	4864	1.0038
fresh.....	15.6 54.4	--- ---	60 130	--- ---	1.13 0.55
sea.....	---	---	---	---	1.15
Water (sea) (surface, 3.5% salinity)	15	1507.4	59	4944	---
Whale oil	37.8 54.4	--- ---	100 130	--- ---	35 - 39.6 19.9 - 23.4
Xylene hexafluoride	25	879	77	2883	---
o-Xylene	20 22	--- 1352	68 72	--- 4435	0.93 ---
Zinc	450	2700	842	8856	---

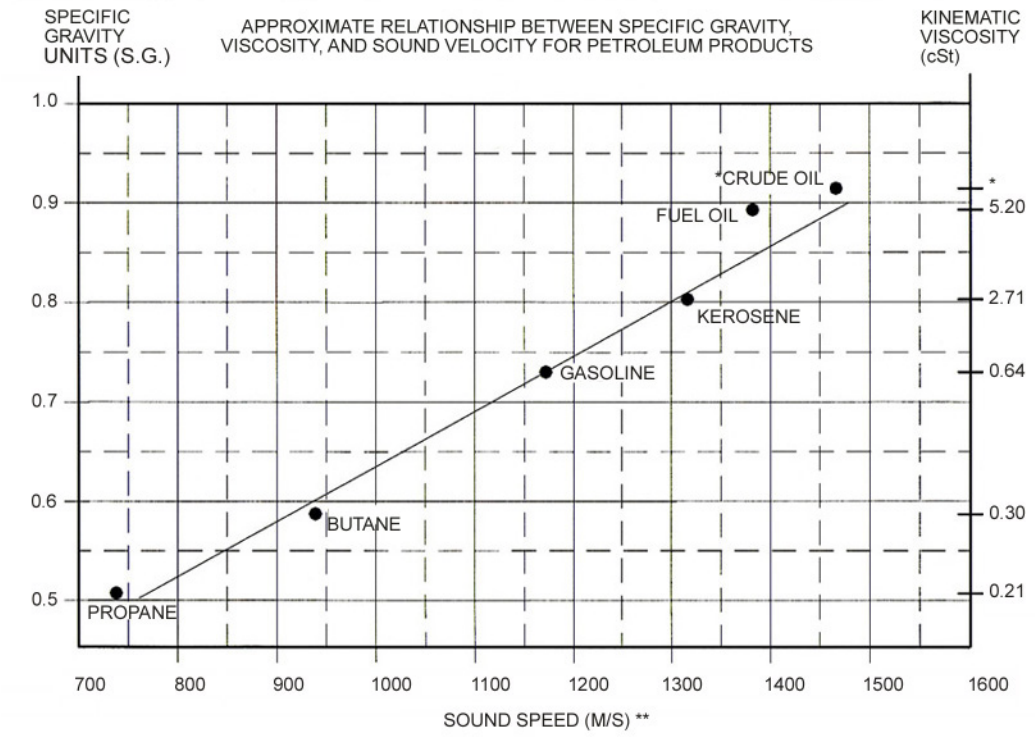
B.2 Clean Water Sound Speed Versus Temperature

Fº	Cº	ft/s	m/s	Fº	Cº	ft/s	m/s
32	0	4599.8	1402.019	131	55	5075.4	1546.982
41	5	4677.8	1425.793	140	60	5087.2	1550.579
50	10	4747	1446.886	149	65	5095.3	1553.047
59	15	4808.3	1465.57	158	70	5099.7	1554.389
68	20	4862.1	1481.968	167	75	5100.8	1554.724
77	25	4909.1	1496.294	176	80	5098.7	1554.084
86	30	4949.9	1508.73	185	85	5093.6	1552.529
95	35	4985	1519.428	194	90	5085.6	1550.091
104	40	5014.7	1528.481	203	95	5074.8	1546.799
113	45	5039.4	1536.009	212	100	5068.4	1544.848
122	50	5059.6	1542.166	*see next page for graphical representation			



B.3 Relationship Between Specific Gravity, Viscosity, & Sound Velocity for Petroleum Products

This figure is a graph showing the approximate relationship between specific gravity, viscosity and sound velocities for aliphatic hydrocarbons (petroleum products).



*SEE TABLE FOR VISCOSITY OF VARIOUS TYPES OF CRUDE OIL
** MULTIPLY M/S BY 3.28 TO OBTAIN FT/S IF ENGLISH UNITS ARE REQUIRED

NOTE:
VISCOSITIES ARE APPROXIMATE. THIS NOMOGRAPH SHOULD BE APPLIED TO ALIPHATIC HYDROCARBONS AND MIXTURES THEREOF ONLY

APPENDIX C: MONITORING & DOWNLOADING DATALOGS USING D-LINK

D-Link is PC-based user interface software that can communicate with DCT6088 and DCT7088 flowmeters to monitor and download datalog information.

C.1 Installing D-Link

Start the PolyCD and select D-Link in Communication Software. Follow the instructions to install D-Link.

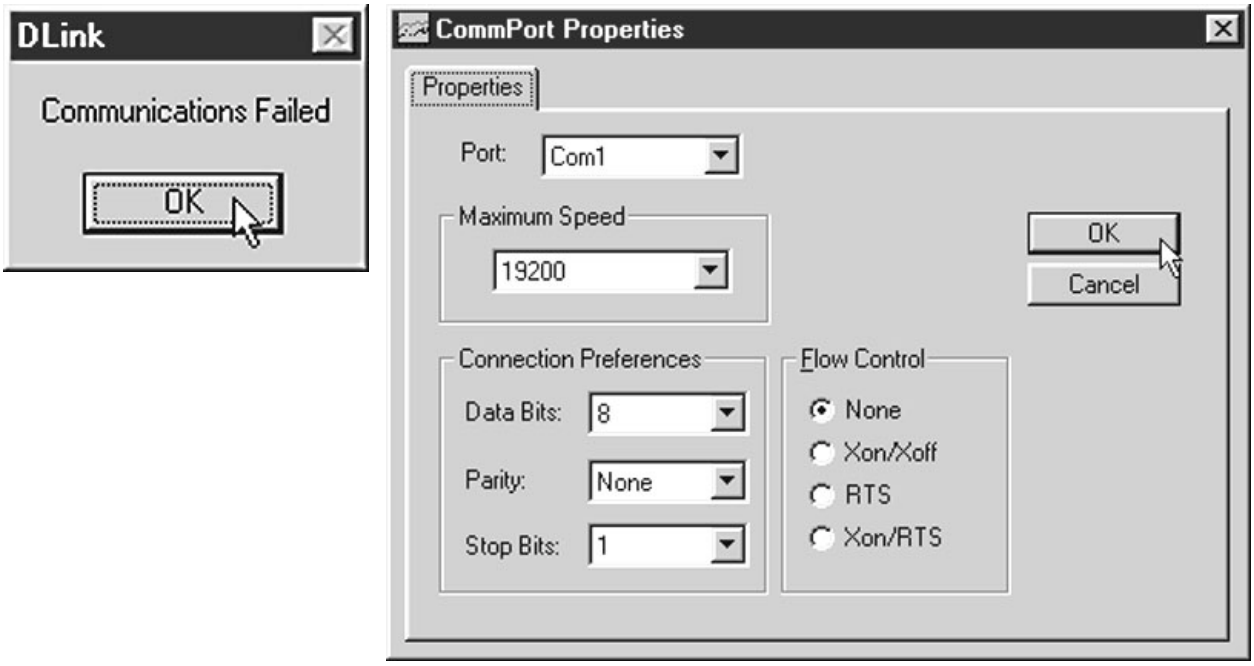
C.2 Establishing Communications with a Flowmeter

1. Go to the **Options Group** menu (42) and select *D-Link* in the communication options.

2. Connect a RS232 cable from the PC to the flowmeter.

3. Open the D-Link utility.

If a *Communication Failed* dialogue opens as shown in Figure C.2-A, click *OK*. Make necessary adjustments according to your PC setup (Figure C.2-B) and click *OK*.



FIGURES C.2-A & C.2-B

If communications still do not establish check the following and correct any errors:

- D-Link is selected in communication Options Menu;
- RS232 cable is connected correctly between the meter and your PC;
- no other software program in your PC is using the COM port you selected.

C.3 Monitoring Datalogs

Once communications between the PC and the meter establish, the program opens as shown in Figure C.3-A (below). Click the arrow below *Get Log*, and select the log file you want to check. Click *Get Log*. The log information downloads and displays as seen in Figure C.3-B (page 77). Log information can be downloaded from the meter when the log is still running, so you can monitor the flow data without stop the log. Refer to Section 4.16 (page 28) for instructions on setting up the datalogger.

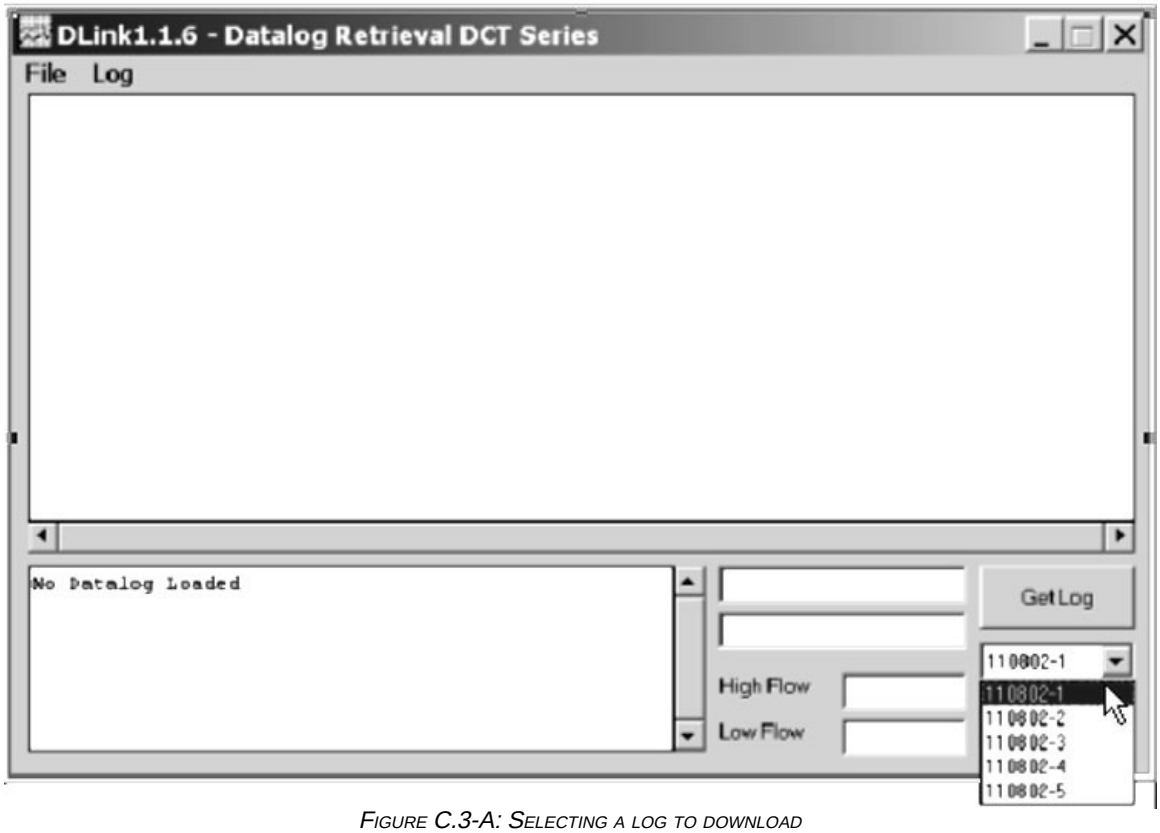


FIGURE C.3-A: SELECTING A LOG TO DOWNLOAD

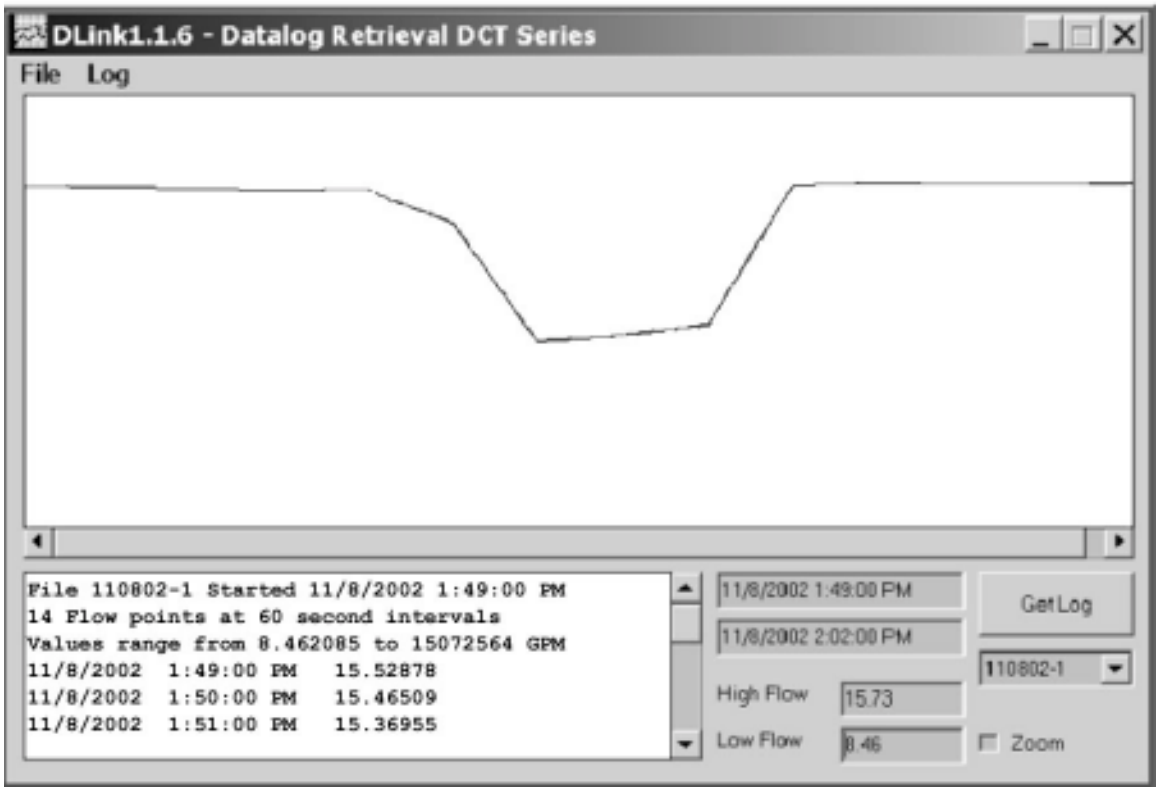


FIGURE C.3-B: DISPLAYED LOG

C.4 Saving & Loading Datalogs

To save the current displayed datalog to a file, go to *File* and select *Save Log.* The file can then be opened in data processing software such as Excel® for Windows®.

To load a previously saved log file, go to *File* and select *Load Log* (refer to Figure C.4, page 78).

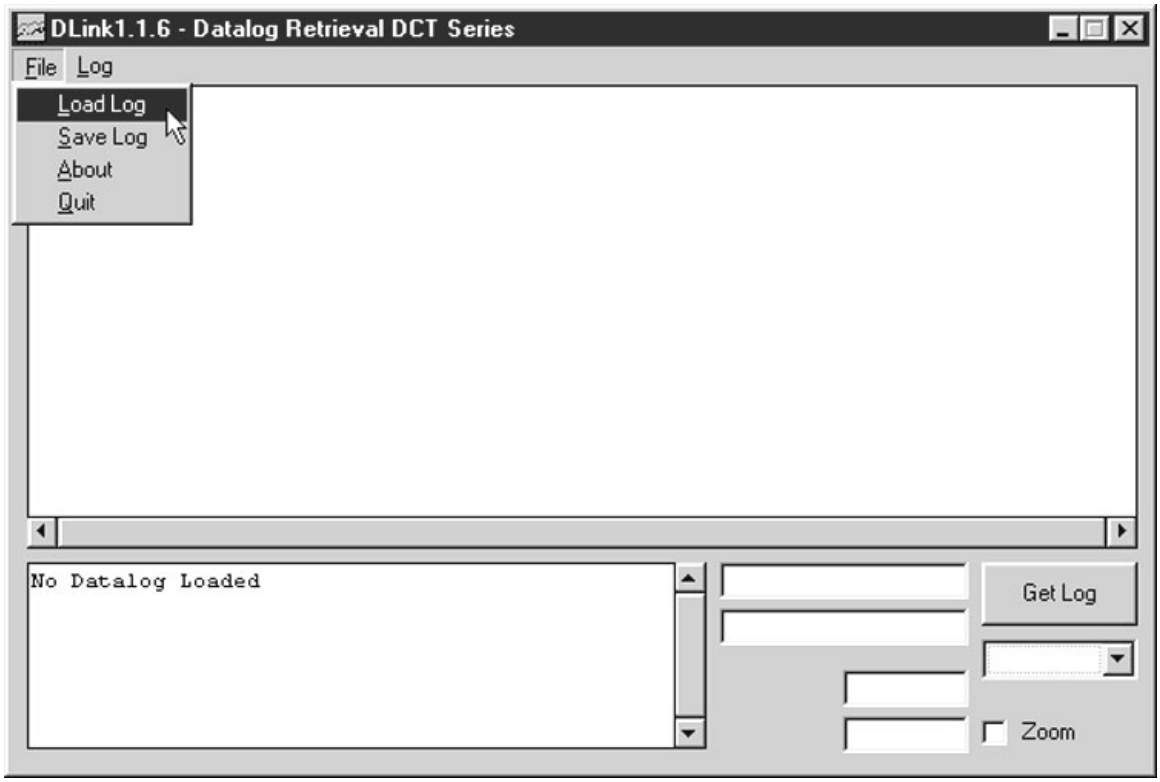

DLink1.1.6 - Datalog Retrieval DCT Series
File
Log
Load Log
Save Log
About
Quit
No Datalog Loaded
Get Log
Zoom

FIGURE C.4